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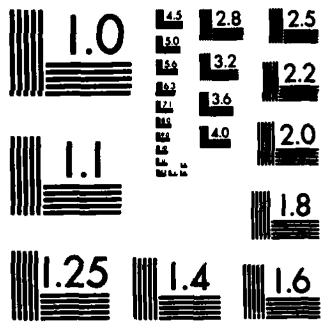

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TECHNICAL REPORT Y-84-2

EVALUATION OF METHODS FOR SAMPLING VEGETATION AND DELINEATING WETLANDS TRANSITION ZONES IN COASTAL WEST-CENTRAL FLORIDA JANUARY 1979-MAY 1981

by

Robin Hart

Environmental Science and Engineering, Inc.
P. O. Box ESE
Gainesville, Fla. 32602

U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

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Eight wetland types in west-central Florida were studied to formulate a method for determining the upper limits of wetlands, defining the boundaries of transition zones, and distinguishing both from the adjacent wetlands. The study was conducted in two phases.

Phase I was an evaluation of vegetation sampling methods to determine procedures that most efficiently achieved an accurate representation of

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changes in abundance and composition of the more common plant species. The best method proved to be sampling of shrubs in 1- × 4-m quadrats and herbs in 1- × 1-m quadrats along contiguous 1-m segments of transects placed parallel to the moisture gradient. Trees were not adequately sampled by the method because the large areas required for adequate sampling often extended past the transition zone into adjacent upland or wetland areas. Frequency and percent cover were found to be the most rapidly employed and useful vegetational parameters for determining wetland boundaries.

Phase II of the study consisted of evaluating two analytical methods for delineating transition zone boundaries. The first method consisted of calculating percent similarity between consecutive quadrats along the transects. The second method involved calculating weighted averages for all species based on the average distance of each species from the wetland endpoint of the transects. Calculation of percent similarity values entailed fewer calculations and provided less ambiguous boundary delineations.

Transition zones of most communities were found to have greater species diversity and different physiognomic forms when compared with adjacent wetlands. However, they aligned more closely with wetlands than with uplands and were composed of species that tended to alternate between wetland and transition zones.

SUMMARY

This study is one of five regional studies of wetland transition zones contracted by the U. S. Army Corps of Engineers Waterways Experiment Station.

Eight wetland types in west-central Florida, representing both freshwater and saltwater marshes and swamps, were studied to formulate a methodology for determining the upper limits of wetlands, defining the boundaries of transition zones, and distinguishing both from the adjacent wetlands. The study was conducted in two phases. Phase I was an evaluation of vegetation sampling methods to determine procedures that most efficiently achieved an accurate representation of the changes in abundance and composition of the more common plant species. Phase II was an evaluation of analytical methods that best delineated transition zone boundaries, using data obtained in Phase I.

Sampling from contiguous plots along 1-m segments of transects, which extended from wetland to upland parallel to the moisture gradient, yielded the most useful data for boundary definition. Recommended plot sizes are 1 by 4 m for shrubs and 1 by 1 m for herbs. Trees present a problem because the large areas required for adequate sampling often extend past the transition zone into adjacent upland or wetland areas.

Frequency and percent cover were recommended as the most rapidly employed and useful vegetational parameters for determining wetland boundaries.

Two methods were employed to delineate a wetland-transition zone boundary and transition zone-upland boundary. The first method consisted of calculating the percent similarity between consecutive quadrats along the moisture gradient; the boundaries were located in quadrats where minimum percent similarity values occurred between adjacent quadrats. The second method involved calculating weighted averages for all species in a community based on the average distance of each species from the wetland endpoint of the transects. These averages, when plotted on a line representing the gradient, identified species groups whose mean intragroup distances were significantly lower than intergroup distances.

The method using percent similarity values entailed less calculation and provided less ambiguous delineation of boundaries.

The study revealed that transition zones of most communities studied had greater species diversity and differed in dominant physiognomic form when compared with the adjacent wetlands. However, they aligned more closely with the wetland than with the upland and were composed of species that tended to alternate between wetland and transition zones in different communities.

PREFACE

This report was prepared by Environmental Science and Engineering, Inc. (ESE) for the U. S. Army Engineer Waterways Experiment Station (WES) under Contract No. DACW39-78-C-0099, dated 30 September 1978. The studies presented in this report were performed during the period January 1979 through July 1981. The report was published as part of the Wetlands Research Program (WRP) at WES. Technical monitors of WRP for the Office, Chief of Engineers, were Dr. John R. Hall and Mr. Phillip C. Pierce.

The field research was designed and directed by Mr. James E. Poppleton and Mr. Anthony N. Arcuri. The report was written by Dr. Robin Hart. Field sampling teams included Mr. John Maxwell, Mr. Anthony Bleecker, and Ms. Ellen Ballard of ESE. Species identification was performed by Mr. Poppleton and Mr. Arcuri. Ms. Charlotte Sykes and Ms. Devorah Levy assisted in production of the report.

Access to the sites near Morris Bridge Road was provided by permission of Mr. Ken Kramer, Supervisor of Land Management, Southwest Florida Water Management District. Investigations in Hillsborough River State Park and on Honeymoon Island were conducted by permission of Mr. James Stevenson, Chief Naturalist, Division of Recreation and Parks, Florida Department of Natural Resources. Access to the salt marsh was provided by the Aripeka Limestone Corporation.

This study was conducted under the direct supervision of Dr. R. T. Huffman of the Wetland and Terrestrial Habitat Group (WTHG), Environmental Resources Division (ERD), Environmental Laboratory (EL), and under the general supervision of Dr. H. K. Smith, WTHG, ERD, EL; Dr. C. J. Kirby, Chief, ERD, EL; and Dr. John Harrison, Chief, EL. Dr. Smith was manager of the WRP.

The Commanders and Directors of WES during the preparation and publication of this study were COL John L. Cannon, CE; COL Nelson P. Conover, CE; and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

This report should be cited as follows:

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	0.4046873	hectares
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
inches	2.54	centimetres
miles (U. S. statute)	1.609347	kilometres

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

EVALUATION OF METHODS FOR SAMPLING VEGETATION AND DELINEATING WETLANDS TRANSITION ZONES IN COASTAL WEST-CENTRAL FLORIDA JANUARY 1979-MAY 1981

PART I: INTRODUCTION

1. The U. S. Army Corps of Engineers' definition of wetlands is: "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." (Federal Register, 1977 Volume 42, p. 37128).

2. However, wetlands are often bordered by a transitional zone of gradual change from hydrophytic vegetation to upland vegetation. This transition zone contains a mixture of hydrophytes, upland species, and some species whose center of distribution is in the zone itself because they compete successfully only where hydrophytes and upland species are at the margins of their distributions. The point within the transition zone at which vegetation typically adapted for life in saturated soil conditions is no longer prevalent is difficult to determine.

3. Plant species usually exhibit normal distributions over some segment of an environmental gradient (Whittaker 1978). In this case, the transition zone represents a moisture gradient based on the combined effect of frequency, duration, and depth of flooding and the depth to water table. The centers of distribution and abundance of species differ along the gradient. Co-occurring species form a continuum of constantly changing composition. The presence of transition zones raises the question of whether the wetland boundary can be clearly and objectively delineated using the current definition.

Objective

4. The objective of this investigation was to formulate a methodology for determining the upper limits of wetlands, defining the

boundaries of transition zones present, and distinguishing both from adjacent uplands in midpeninsular Florida. The transition zone is defined as a zone between an area containing only hydrophytic species and an upland area in which all species present are intolerant to prolonged, saturated soil conditions within the root zone during the growing season.

Approach

5. Boundaries should be determined along points where natural groups or clusters of species can be related to the moisture gradient. In this way, boundaries can be ecologically determined and are most likely to delineate the area in the transition zone where disturbance would critically affect the wetlands. The selected method should be applicable to many types of wetland sites, including disturbed communities, and it should be clear, unambiguous, and technically reproducible so as to be legally defensible when wetland boundary determinations are challenged in court.

6. It was desired that the chosen methodology should not rely upon the presence of particular species in any of the wetland types studied. The prevalence of so-called "indicator" species is not a valid method for determining wetland boundaries because species presence and abundance can be influenced by factors other than moisture (e.g., disturbance, stress from predators, pathogens, weather extremes, competitive interactions, and stochastic (random) variations in species distribution).

7. Because the boundary was to be defined by changes in vegetation along the moisture gradient, sampling methods that accurately and efficiently depict the location and nature of the changes in vegetation were crucial to the success and validity of this investigation.

8. For this reason, the study was conducted in two phases:

   a. Phase I--An evaluation of vegetation sampling methods to determine procedures that most efficiently achieved an accurate representation of the changes in abundance and composition of the more common plant species in various

wetland and transitional plant communities. This evaluation consisted first of a literature review to select the most appropriate methods for field testing (ESE 1979). Selected methods were than analyzed by field testing to determine those that were most useful in peninsular Florida.

b. Phase II--Use of the data acquired during the sampling evaluation to develop an analytical method that best delineated a natural boundary between the species most closely associated with the wetland community and those more appropriately grouped with upland species.

9. Four sites were chosen to field test several widely used sampling methods for accuracy and efficiency. These sites were located along the edges of wetland communities that differed in physiognomic structure. When these field tests were completed, the results were compared to determine the methods that were most suitable (Phase I). Four additional wetland communities were then sampled in Phase II using the methods selected in Phase I.

10. The data from all eight communities were analyzed using percent similarity (PS) and weighted average (WA) methods to delineate transition zone boundaries. The utility of these methods and other considerations are discussed in the final section of this report.

Description of the Region

Introduction

11. This study was conducted in west-central Florida (Hillsborough, Hernando, and Pinellas counties). Most of the wetlands work in Florida has been devoted to classification of wetland types and environmental tolerances of individual species. Monk (1965) ordinated tree species of north-central Florida along several environmental variables, including a moisture gradient. Otherwise, little effort has been expended in studying wetland transition zones in Florida. Florida wetland types differ substantially from wetlands in other regions of the United States because of the geology, physiography, and climate peculiar to peninsular Florida. A description of the regional environment and general wetland types found in Florida is included to provide an understanding

of the problems specific to wetland boundary delineation in the State.

Geology

12. The projection of the North American continent separating the Atlantic Ocean from the Gulf of Mexico is known as the Floridian plateau (Cooke 1945). This plateau supports peninsular Florida, a gently emergent peninsula with a maximum height of 99 m above sea level.

13. The immediate surface at most places in Florida is underlain by Pleistocene deposits. The most widely distributed deposit in the study area is a series of seven sandy formations corresponding to terraces resulting from seven different stages of sea level. The core of the Floridian plateau is probably composed of ancient metamorphic rocks like those of the Piedmont region of Georgia (Cooke 1945).

14. The land surface of the study area rises inland from the Gulf of Mexico across the Coastal Lowlands marine plain to a series of essentially north-south elongated ridges and bars of low relief that characterize the Central Highlands. Geologists conjecture that these ridges were barrier islands or beach ridges that formed along ancient shorelines. These ridges, together with the poorly drained plains along the coast and the slightly rolling alluvial plains and shallow valleys of the major rivers, constitute the principal types of terrain found in the study area.

Climate

15. The climate of the study area is subtropical. Annual temperature averages 72° to 73° F*, and monthly averages range from 61° F in January to 82° F in July and August. Seasonal and diurnal temperature variations are less pronounced than in the inland areas, which are not under the moderating influence of the Gulf of Mexico. The annual rainfall averages 134.6 cm and is highly seasonal. More than one-half of the annual rainfall occurs during the months of June through September; the driest months occur in the winter.

Soils

16. Most soils of the study area are young and underdeveloped; nearly level or gently sloping; acidic; very sandy with high permeability;

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 8.

and generally low in clay, organic matter, and plant nutrients (Beckenbach 1973). Peat forms and accumulates in areas of exceptionally poor drainage.

Vegetation

17. Sandy soils, highly seasonal precipitation, low relief and elevation, poor drainage, and a mild climate are the major influences on the vegetation types found in central Florida. Many temperate zone species are at their southern limits, some tropical species are at their northern limits, and numerous species are endemic. Several exotic species, originally imported for cultivation, have invaded extensively disturbed areas and have not been replaced by native vegetation. These exotics include Brazilian pepper bush (*Schinus terebinthifolius*), melaleuca (*Melalueca quinquenervia*), and waterhyacinth (*Eichhornia crassipes*) (Austin 1978).

18. A feature of Florida's geography of special importance to wetlands is the minor difference in elevation that results in striking changes in vegetation types. This feature is typical of the coastal plain where vegetative differences that occur over moisture gradients are as sharp as those that occur in regions of higher relief (Whittaker 1979).

19. Upland plant communities. Upland plant communities in Florida are defined by the Florida Land Use/Cover Classification System--Level III (Division of State Planning 1976) as follows:

Coniferous Forest

a. Pine flatwoods--Forested (i.e., tree-crown areal density of 10 percent or more) area dominated by longleaf pine (*Pinus palustris*) on the drier sites and slash pine (*Pinus elliottii*) on the wetter areas. The typical understory is saw palmetto (*Serenoa repens*), wiregrass (*Aristida* spp.), wax myrtle (*Myrica cerifera*), fetterbush (*Lyonia* spp.), and gallberry (*Ilex glabra*). Typically, the pines form a sparse canopy with no significant encroachment of hardwoods, because of periodic burning. Pine flatwoods are the most common and the most floristically diverse upland type in Florida (Long 1974).

b. Longleaf pine-xeric oak--Dominated by longleaf pine, with bluejack oak (*Quercus incana*), turkey oak (*Quercus laevis*), and post oak (*Quercus stellata*) being the most common

understory trees. Wiregrass (*Aristida stricta*) is the most prevalent herbaceous species. These areas are located on well-drained upland sand; sandhill is another term commonly used to describe this community.

c. Sand pine scrub--The dominant overstory tree is sand pine (*Pinus clausa*). Typical understory trees are myrtle oak (*Quercus myrtifolia*), Chapman's oak (*Quercus chapmanii*), and sand live oak (*Quercus geminata*). This forested area occurs on excessively drained sands.

Hardwood Forest

d. Xeric oak--This forest type, located on well-drained upland sands, is dominated by xeric oak species. Typical oak species are those listed in b and c; however, pines are absent.

e. Other hardwood forest--Typical species in the canopy are: live oak (*Quercus virginiana*), laurel oak (*Quercus laurifolia*), water oak (*Quercus nigra*), sweetgum (*Liquidambar styraciflua*), and southern magnolia (*Magnolia grandiflora*). Tropical hardwood hammocks are in this category. Fire is particularly damaging to hardwood forests (Edmisten 1963). In contrast, the other upland communities are maintained by fire (Hofstetter 1974).

20. Wetland plant communities.* Wetlands in Florida differ with regard to physiognomy, species composition, hydroperiod, soils, and degree of salinity. Wetland communities and their dominant vegetation in Florida, as defined by the Environmental Effects Laboratory of WES (1978), include:

a. Saltwater aquatic--Permanently flooded by saline or brackish water. Dominated by attached or free-floating herbaceous plants, including macroscopic marine algae. Distributed along the coast below the intertidal zone. Turtle grass (*Thalassis testudinum*) is a typical species.

b. Saltwater coastal flat--25 percent or less vegetative cover. Occasionally or regularly flooded by saline water of tidal origin. Intermittent along the coast, flooded only at high tide. Few plants can withstand the hypersaline substrate. Typical species are widgeon grass (*Ruppia maritima*) in the deep flats and saltwort (*Batis maritima*) in shallow flats.

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* National Wetlands Inventory (NWI) equivalents of wetland types mentioned in this report are presented in Appendix E.

c. Saltwater marsh--More than 25 percent vegetative cover of herbaceous plants, but 40 percent or less woody plant cover. Occasionally or regularly flooded by brackish or saline water. Found along most of the coast. Typical species are cordgrasses (*Spartina* spp.) and black needlerush (*Juncus roemerianus*).

d. Saltwater swamp--More than 40 percent woody plant cover. Occasionally or regularly flooded by brackish or saline water. Mangrove dominates saltwater swamps in Florida.

e. Freshwater aquatic--Semipermanently or permanently flooded by fresh water. Dominated by free-floating or rooted aquatic herbs such as watermilfoil (*Myriophyllum* spp.) and waterlily (*Nymphaea* spp.). Occurs in streams, rivers, canals, ponds, lakes, and reservoirs.

f. Freshwater flat--25 percent or less vegetative cover. Occasionally or regularly flooded by fresh water. Usually surrounds areas of fluctuating water levels. Sparsely vegetated with open stands of weedy herbs, shrubs, and trees. Typical species are willow (*Salix* spp.) and groundsel (*Baccharis halimifolia*).

g. Freshwater marsh--More than 25 percent herbaceous plant cover, but 40 percent or less woody plant cover. Occasionally or regularly flooded by freshwater. Scattered throughout inland Florida; the largest is the 1.01-million-ha Everglades. Sawgrass (*Cladium jamaicense*) and maidencane (*Panicum hemitomon*) are typical dominants.

h. Freshwater swamp--More than 40 percent woody cover. Occasionally or regularly flooded by fresh water. Occur in bands along drainages or in circular-shaped depressions. Can be further classified by dominant woody species: cypress swamp, bayhead (broadleaved evergreens), and mixed hardwood (broadleaved deciduous).

Environmental Determinants of Wetland Types Selected for Study

21. Swamps and marshes were selected for the study. Aquatic wetlands and coastal flats usually border other wetland types; therefore, there is no upland-wetland transition to analyze. The dominant physiognomic types and species in swamps and marshes are determined by interaction of hydroperiod, exposure to fire, and disturbances (e.g., selective logging).

Freshwater marshes

22. Freshwater marshes are wetlands inundated by freshwater in a

situation which, by reason of disturbance, fire, or hydroperiod, excludes trees (Figure 1). Often, water retention in isolated marshes is due to the presence of a clay lens a few feet below the surface. Marshes also border open waterbodies. Freshwater marshes contain a mixture of hydrophytic plant species that varies in composition among sites, depending on local water and soil conditions. Dominant species often are distributed in concentric rings or parallel zones representing changes in hydroperiod along the moisture gradient. Marshes occur in areas with hydroperiods ranging from 60 to 250 days. They may persist where there are short hydroperiods and frequent fire or where there are long hydroperiods and less frequent fire. Either combination tends to exclude invasion by woody plants (Duever and Spangler 1979). Marsh communities normally undergo changes in community structure through different seral stages leading to the formation of swamps (Wharton et al. 1976).

Freshwater swamps

23. Freshwater swamps usually are dominated by trees, but they may be dominated by shrubs such as water ash (*Fraxinus caroliniana*) or primrose willow (*Ludwigia peruviana*) in the seral stages. Freshwater swamps include alluvial cypress swamps, cypress domes, bayheads, and broadleaved-deciduous swamps, which are described as follows:

a. Alluvial cypress swamps occur along river floodplains at lower elevations adjacent to hardwood hammocks. The higher margins of the swamp vegetation often grade into the hammock vegetation, which occurs at slightly higher elevations (Wharton et al. 1976). The dominant species in river swamps is bald cypress (*Taxodium distichum*).

b. Cypress domes characteristically exhibit symmetrical dome shapes and occur in poorly drained depressions within pine flatwood communities. The dominant species in domes is pond cypress (*Taxodium ascendens*).

c. Bayheads are characterized by a canopy composed of evergreen hardwood species such as sweet bay magnolia (*Magnolia virginiana*) and loblolly bay (*Gordonia lasianthus*). A subcanopy comprised of dahoon holly (*Ilex cassine*) and swamp red bay (*Persea palustris*) is common. Shrub and herb taxa found in these swamps are similar to those of cypress swamps.

d. Broadleaved-deciduous swamps typically occur within the floodplains of rivers and streams. The high diversity of

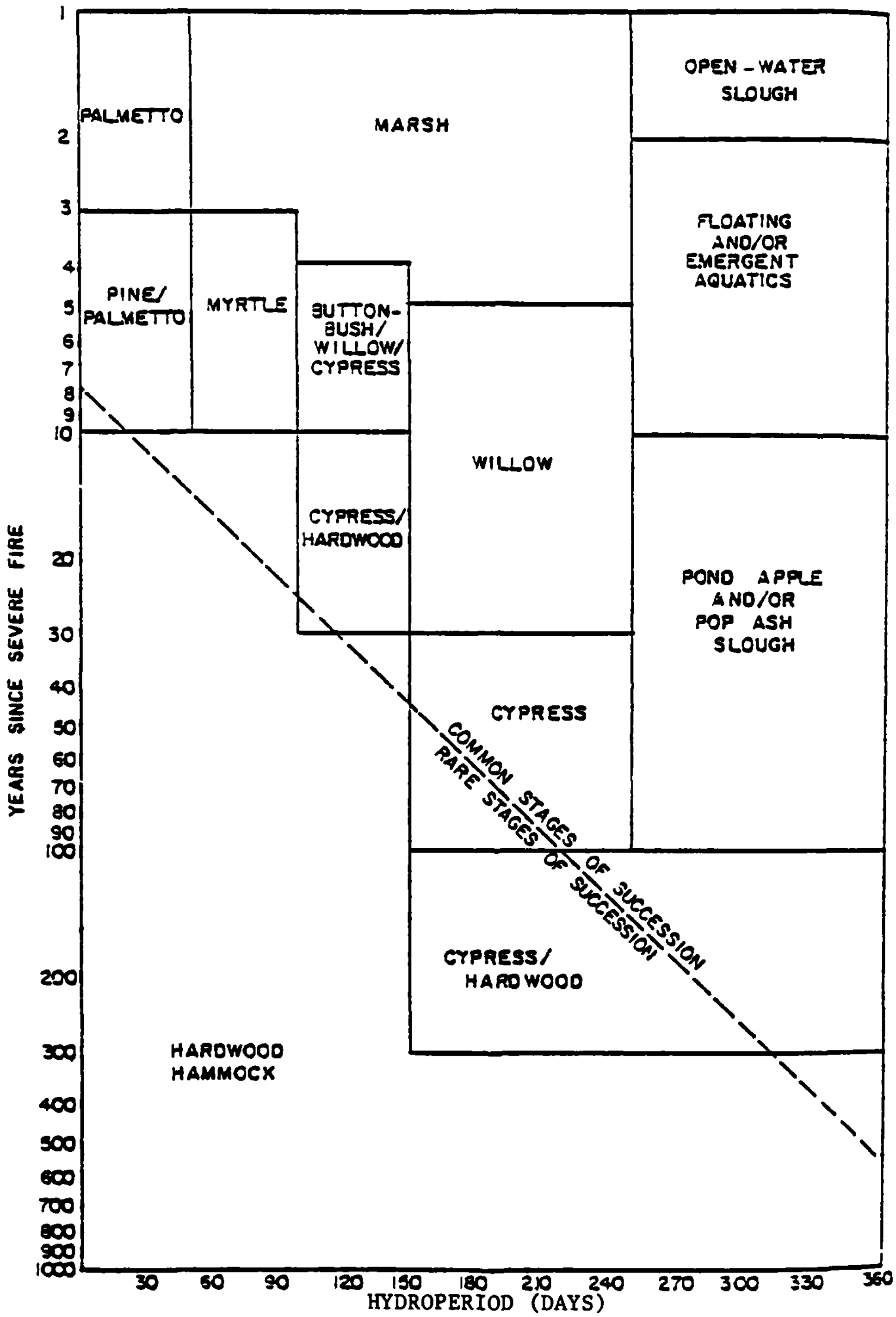

Figure 1. Successional patterns and rates in inland plant communities in South Florida (Duever and Spangler 1979)

tree species includes swamp tupelo (*Nyssa sylvatica* var. *biflora*), red maple (*Acer rubrum*), sweetgum, laurel oak, cabbage palm (*Sabal palmetto*), water oak, and Florida elm (*Ulmus americana* var. *floridana*).

24. Ranked in order of decreasing tolerance to fire are marshes, shrub swamps, pond cypress swamps, bayheads, and broadleaved-deciduous swamps. The relationship between these communities is illustrated in Figures 1 and 2. Therefore, the community type present in any freshwater wetland of peninsular Florida depends not only on the hydroperiod and position along a moisture gradient, but also on fire frequency and length of the period since the last fire or disturbance.

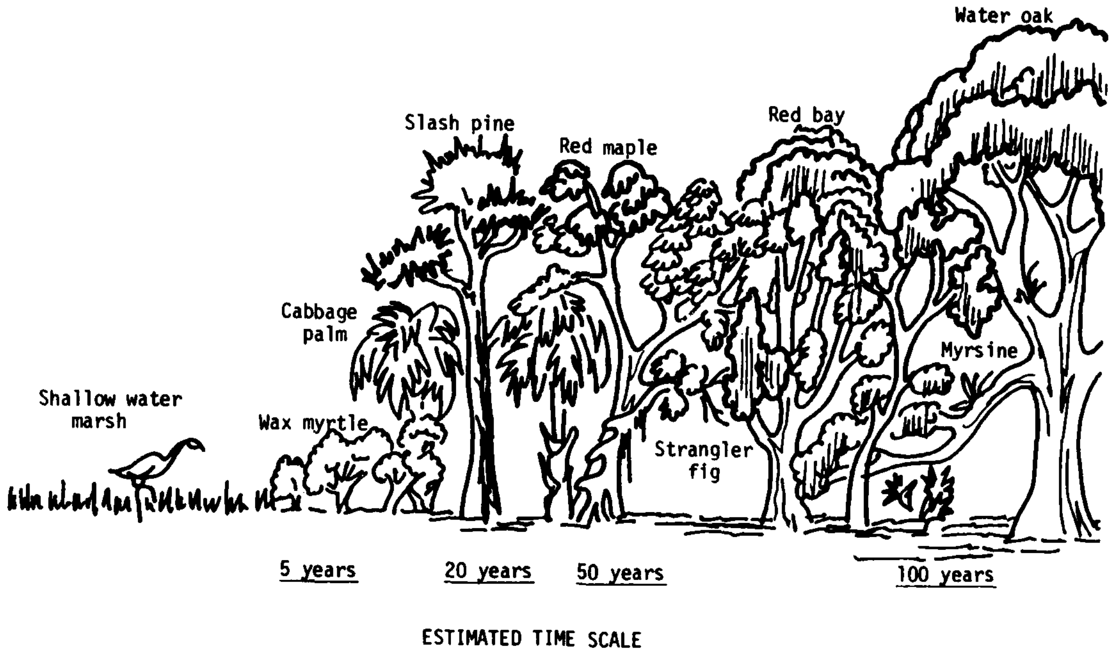

Figure 2. South Florida successional patterns without fire: shallow-water marsh to hammock (Wharton et al. 1976)

25. Saltwater marshes may form narrow fringes along the coast or extend several miles inland. Several distinct salt marsh communities may occur within an elevation of a few centimetres. Generally, the salt marshes can be separated into two types: high marsh and low marsh. The high marsh occupies the highest elevations that are still subject to normal influences of the tide, whereas the low marsh occupies the lower

elevations and experiences longer periods of flooding than the high marsh. In less saline, high saltwater marshes, black needlerush and smooth cordgrass (*Spartina alterniflora*) predominate, often in extensive stands. The low saltwater marshes experiencing the longest periods of inundation are characteristically low in species diversity and are often dominated exclusively by smooth cordgrass.

26. Saltwater swamps occur along the peninsular Florida coast in tidal rivers, creeks, bays, and estuaries. Species present such as red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erecta*) exhibit distinct zonation. Red mangrove usually occurs along the water's edge and is flooded at low tide. Black mangrove is typically dominant on soils exposed by low tides but flooded by high tides. White mangrove often forms monotypic stands in areas inundated only during very high tides. Occasionally, the most landward zone will be dominated by buttonwood or a combination of white mangrove and buttonwood.

27. Mangrove forests have increased in area in recent decades due to encroachment into formerly freshwater areas (Alexander and Crook 1974). In this invading stage, red and white mangroves occur together in the intertidal area. Eventually, red mangrove dominates, and white mangrove is found only above the mean high-water elevation (Ball 1980).

PART II: EVALUATION OF SAMPLING METHODOLOGY

Phase I: Field Evaluation of Methods

Quantitative sampling methods

28. The choice of methods for sampling vegetation depends on the purpose for sampling. When a detailed description of a community is required, sampling should be adequate to describe the distribution and relative abundance of all species present. A study of community productivity would require less attention to species composition, but accurate measures of total biomass would be important.

29. This study required a sampling program that would accurately depict the collective change in species composition and abundance along a moisture gradient that would enable location of the point between wetland and upland where the most rapid change occurs. The location, number, and size of sampling points, as well as the parameters to be measured, were selected accordingly. The purpose of this study imposed constraints on sampling methodology, as described in the following paragraphs.

30. The sampling points should be located along transects parallel to the moisture gradient. However, the points within any zone must be randomly selected so that valid statistical analysis can be performed (Greig-Smith 1964).

31. An adequate number of individuals of a species must be sampled to determine the points where significant change in its abundance occurs along the gradient. Infrequently occurring species could not be used to define the location of the transition zone and would require an inordinate amount of sampling to yield reliable information on abundance and distribution. Only the more frequently occurring species should be sampled.

32. The size and number of sampling points must be sufficient to minimize sampling variation. Plot size should be appropriate to the size and dispersion of the plants within the community. Plots that are too small will include only one or a few species, and species variability among plots will be high. Plots that are too large will have dissimilar replicates because they will extend over a heterogeneous environment.

Optimum plot size will maximize the floristic similarity of replicate plots. Since gradient changes are being measured, the plot size must not only be sufficient to include a representative sample of the species within a zone, but must be sufficiently narrow so as not to obscure changes in vegetation occurring along the gradient.

33. Any vegetational parameter used should be a sensitive indicator of species importance; i.e., an indicator of the location along the gradient where a species is most favored in comparison with other species present in the community. The chosen parameters should be comparable between strata so that trees, shrubs, and herbs can all be used to measure response to change in gradient. Individual counts per area (density) are independent of plot size. However, counts are tedious and, for herbaceous plants, often inaccurate because of the difficulty in distinguishing between individuals. Percent cover and/or frequency can be measured much more rapidly than density (Wikum and Shanholtzer 1978, Smartt, Meacock, and Lambert 1976). However, these two measures are influenced by plot size.

34. Percent cover is defined for this study as the estimate of the percent of a plot occupied by a projection of the species canopy on the ground.

35. Density is defined for this study as the number of individuals per unit area. Individuals are defined as aerial stems, even though they may be connected by roots or rhizomes.

36. Frequency describes the distribution of a species in an area, and is defined for this study as the number of sample points in which a species occurs divided by the total number of sample points. Sample points refer to plots or, for plotless methods, the points from which individuals are sampled.

37. The methods selected for field evaluation are described below. Sampling was conducted in July and August 1979.

38. Trees. The tree stratum was defined as that stratum consisting of woody species with trunk diameter equal to or exceeding 2 cm. Quadrangular plots (quadrats) of 25 m^2 and 100 m^2 were tested (Table 1).

39. The point-centered quarter method also was used to sample

Table 1

Sampling Methods Tested in Each Community

Method	Cypress Swamp	Freshwater Marsh	Freshwater Shrub	Saltwater Marsh
		Tree Stratum		
Wandering quarter				X
Point-centered quarter	X	X*	X	X*
Plot sampling:				
20 m by 5 m	X	X	X	X
5 m by 5 m	X	X	X	X
Belt transect	X	X	X	X
		Shrub Stratum		
Plot sampling:				
2 m by 2 m	X	X	X	X
4 m by 1 m	X	X	X	X
8 m by 2 m	X	X	X	X
2 m by 1 m	X	X	X	X
4 m by 4 m	X	X	X	X
Belt transect	X	X	X	X
		Herb Stratum		
Plot sampling:				
1-m^2 circles		X		X
2 m by 1/2 m	X	X	X	X
1 m by 1 m	X	X	X	X
Belt transect	X	X	X	X

* Trees are absent from wetland, but present in transition and adjacent upland zones.

trees. This method can be performed rapidly to yield the same information as quadrats. The point-centered quarter method is considered to be the most effective plotless sampling method (Cottam and Curtis 1956).

40. In the point-centered quarter method, four quadrants are established at each randomly selected sampling point through a cross formed by the two lines. One line parallels the moisture gradient and the second is perpendicular to the moisture gradient. The distance to the midpoint of the nearest tree from the sampling point is measured in each quadrant.

41. The four distances of a number of sampling points are averaged, and the square of the average distance equals the mean area occupied by each tree. Other parameters obtained are species, relative density, relative dominance, and relative frequency.

42. The limitations or assumptions of this method (Mueller-Dombois and Ellenberg 1974) are as follows:

- a. Individuals must be located within each quarter, unless a correction table is used for missing points (Warde and Petronka 1981).
- b. Individuals should not be measured twice.
- c. Adequacy of number of sampling points should be determined by plotting the running or cumulative mean.

43. The wandering quarter method (Catana 1963) compensates for some of the limitations of the point-centered quarter method. A quarter is established at a sampling point and is laid out at a predetermined compass direction that divides the quarter into two 45-deg, pie-shaped sections. The nearest tree to the point within the quarter is measured and then becomes the vector of a second quarter that is laid out in the same direction as the first and continued for 25 distance units in one compass direction. This method was tested within the uplands at the saltwater marsh site.

44. Table 1 shows the tree sampling methods used at each site. For all tree sampling methods, basal area, density, and frequency of each species were determined. An Importance Value (IV) for each species was calculated by summing the relative density, relative dominance, and relative frequency.

45. The IV averages two or three vegetational parameters to provide an estimate of the relative success of each species in the stand. Density alone may not be adequate because species represented by young

saplings may have high density and frequency, but low basal area. Conversely, mature individuals may have low density, but basal area may be high. A more balanced representation of species importance is obtained by summing the values for these parameters. For the purposes of this study, use of species importance values is more meaningful than individual vegetational parameters, because the relative change in co-occurring species illustrates response to gradient changes better than do absolute changes.

46. Relative dominance, relative density, and relative frequency were calculated as follows:

$$\text{Relative dominance} = \frac{\text{Basal area of a species}}{\text{Total basal area of all species}} \times 100$$

$$\text{Relative density} = \frac{\text{Number of individuals of a species}}{\text{Total number of individuals}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequencies of a species}}{\text{Total frequencies of all species}} \times 100$$

47. Shrubs. The shrub stratum was defined as including woody species greater than 1 m high and less than 2 cm in stem diameter at 10 cm from the base. Tested quadrat sizes ranged from 2 m^2 to 16 m^2 and included squares and rectangles (Table 1). Rectangular quadrats with long axes perpendicular to the gradient will adequately sample zonal vegetation and yet allow gradient changes to be recognized. However, error due to the edge effect has been reported to be greater in rectangles (Greig-Smith 1964). Edge effect in sampling error is due to the bias of the investigator in selecting the individuals on the quadrat perimeter that are to be included.

48. Density, percent cover, and frequency were determined for each species. The IV was calculated by summing relative density, relative dominance, and relative frequency. Relative dominance was calculated as follows:

$$\text{Relative dominance} = \frac{\text{Percent cover of a species}}{\text{Total percent cover of all species}} \times 100$$

Relative density and relative frequency were determined as in paragraph 46. Only species rooted in the quadrats were measured. Woody vines were considered to be a component of the shrub stratum.

49. Herbs. The herbaceous stratum was defined as all herbaceous species plus woody species less than 1 m in height. The quadrat size used for this stratum was 1 m^2. Quadrats (2 by 0.5 m and 1 by 1 m) and circles (1 m^2) were used as sample plots (Table 1). Percent cover and frequency were measured for all communities; in some, density was recorded as well. The IV was calculated by summing relative dominance and relative frequency for each species.

Belt transects

50. In addition to the quadrat and distance methods previously described, all communities were sampled by belt transects that extended from wetland zones to upland zones parallel to the moisture gradient. These transects consisted of contiguous nested quadrats, 1 by 1 m for herbs and 1 by 2 m for woody species. The presence of species in all strata was recorded for each quadrat. Since the quadrats on these transects were contiguous, these transects were very sensitive to vegetational changes along the gradient. These transects also were used to evaluate frequency data for boundary delineation.

51. Species nomenclature follows Radford (1968), Long and Lakela (1976), and the University of South Florida herbarium.

Adequacy of sampling methods

52. Species-area curves and a running standard error of the mean (SEM) of total percent cover or density of all species calculated with each additional sampling replicate were used to determine when sufficient replicates had been measured. The species-area curve alone is a questionable criterion (Rice and Kelting 1955), although ESE experience has shown it to be a useful guide in the field for obtaining a representative species composition. Therefore, SEM also was used as a measure of sufficient sampling. The SEM is an estimate of the precision of the mean value of a variable (Greig-Smith 1964). It is a measure of the degree of variability of the sample mean of successive measurements around a true population mean.

53. The SEM was calculated as follows:

$$SEM = \sqrt{s^2/n} \quad \text{with } n - 1 \text{ degrees of freedom}$$

where

$$s^2 = \text{the variance of the mean} = \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{(n - 1)}$$

n = the number of sample units within the study area

x = individual values of sample units

54. When the SEM of total cover was graphed against the number of plots sampled, the point at which fluctuations leveled out and the SEM remained relatively unchanged indicated adequate sampling.

55. Often, a desired precision is obtained by sampling the number of replicates required to reach a SEM, which is a specified percentage of the mean (e.g., 15 percent). With a 15 percent SEM, it is probable that 67 percent of the means calculated will be within 15 percent of the true mean, and that the remaining 33 percent of the calculated means would be more than 15 percent away from the true value (Lindsey, Barton, and Miles 1958).

56. However, data from this investigation in Florida indicated that SEM curves for different strata and sites often leveled out at different values, such that a specified precision for all data sets was impractical. The SEM curves did, however, consistently level out, so that the point at which each curve leveled out was selected as a consistent indicator of adequacy for this study. However, it should be noted that sampling adequacy for some methods would require more effort if a specified precision was desired.

Criteria for evaluating methods

57. The following criteria were used to determine methods that produced the most useful results:

a. Accuracy--The estimates of species composition and importance obtained by a sampling method should be close to the true values. Accuracy of species composition was determined by noting methods that provided the most similar

floristic composition between replicates. Accuracy of species importance was determined by assuming that the average IV of all the methods for a given species is the most accurate estimate of its importance in the zone. Each method was compared with this average to determine which method yielded the value closest to the average.

b. Efficiency--The method that required the least amount of time to achieve a leveling of the SEM and a leveling of the species-area curves was judged to be most efficient. The time required is a function of the number of replicates required to achieve leveling of the SEM and species-area curves and the time required to sample one point or plot.

58. These two criteria were applied to all Phase I methods to determine the methods to be used in the field verification phase of the study.

Selection of study sites

59. To be considered a potential site, a location had to meet certain criteria: (a) having characteristics of community types of the region, (b) providing a gradient from wetland to upland zones with a minimal degree of disturbance, (c) providing a stand size of largely homogeneous vegetation sufficient for use with each sampling method, and (d) being very likely to remain in its natural state. Sites selected for the evaluation phase were two freshwater swamps and two marsh types, one fresh water and one salt water.

60. Freshwater sites. The three freshwater sites included a marsh, cypress swamp, and shrub swamp located in Hillsborough River State Park in east Hillsborough County, north of U.S. 301, 19.3 km northeast of Tampa (Figure 3). These wetland sites are located in T27, R21E, S8 of the USGS Zephyrhills Quadrangle. Several types of freshwater wetland communities exist in a relatively pristine state within this approximately 1214-ha park. Cypress domes, marshes, and ponds are numerous. Some of the marshes show successional trends to swamp vegetation, with primary invasion of several shrub species such as primrose willow, buttonbush (*Cephalanthus occidentalis*), and willow (*Salix caroliniana*). These marshes also exhibit secondary invasion of several swamp tree species such as red maple, swamp tupelo, and sweetgum.

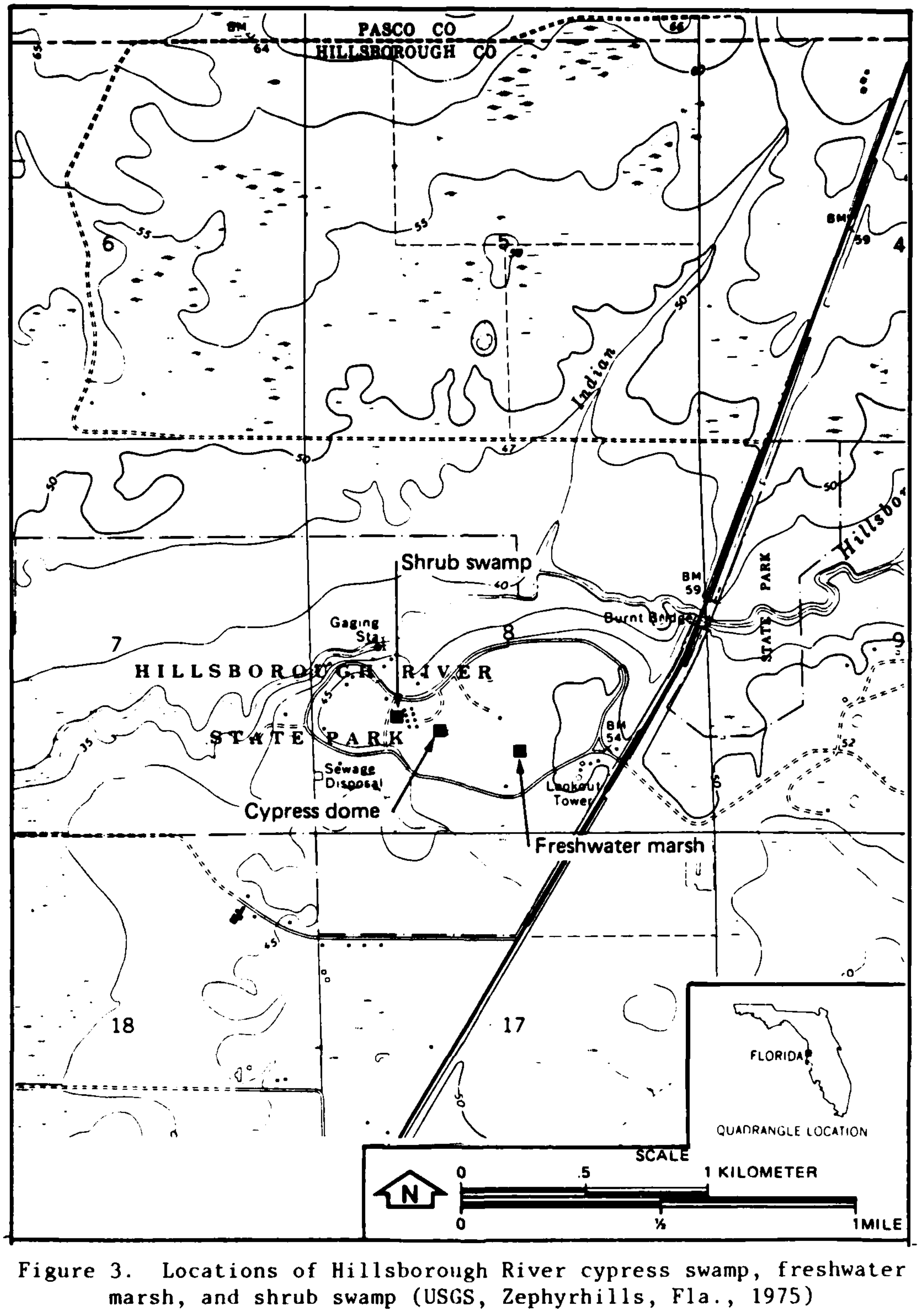

Figure 3. Locations of Hillsborough River cypress swamp, freshwater marsh, and shrub swamp (USGS, Zephyrhills, Fla., 1975)

61. The upland surrounding the marsh, shrub swamp, and cypress swamp at the Hillsborough River State Park consisted of pine flatwoods. The overstory canopy consisted of widely spaced longleaf pine; the understory contained numerous water oak. The shrub layer was dominated by saw palmetto, with other shrubs such as rusty lyonia (*Lyonia fruticosa*) and gallberry. Vines such as muscadine grape (*Vitis rotundifolia*) and greenbriar species (*Smilax bona-nox* and *S. auriculata*) were abundant.

62. Herbs were abundant in open patches. Wire grass, beak rushes (*Rhynchospora* spp.), and panic grasses (*Dichanthelium* spp.) were most common.

63. Marsh. The transition from marsh to upland was abrupt, perhaps due to a fire ditch constructed around the perimeter. Marsh fleabanes (*Pluchea* spp.), yellow-eyed grasses (*Xyris* spp.), pipewort (*Eriocaulon decangulare*), and beak rush characterized the transition zone.

64. Four vegetational zones were evident within the marsh. Toward the center, there was a zone dominated by floating hearts (*Nymphoides aquatica*), beak rush, and yellow-eyed grass. This central zone was surrounded by zone dominated by horned rush (*Rhynchospora inundata*), maidencane, and beak rush. Pickerelweed (*Pontederia cordata*), arrowhead (*Sagittaria lancifolia*), maidencane, and white waterlily (*Nymphaea odorata*) were characteristic of the next zone. The outer zone was dominated by buttonbush and sawgrass.

65. Cypress swamp. Water oak, sweetgum, and a broad herbaceous layer characterized the border between the swamp and upland. Beardgrasses (*Andropogon* spp.), blue maidencane (*Amphicarpum muhlenbergianum*), and pipewort were conspicuous vegetational elements.

66. In the swamp, pond cypress, wax myrtle, and swamp fern (*Blechnum serrulatum*) dominated the tree, shrub, and herb strata, respectively. At the time of sampling, standing water occurred only in isolated pools, although the soil is permanently saturated.

67. Shrub swamp. The shrub swamp was circular and occurred in a very low depression area. Standing water occurred in the swamp at the time of sampling. The transition zone was dominated by herbs and a

dense growth of primrose willow. The center of the swamp contained a pure patch of sawgrass, bordered by cattails (*Typha domingensis*), primrose willow, and giant duckweed (*Spirodela polyrrhiza*).

68. Saltwater sites. The salt marsh site was located on the gulf coast north of Aripeka in Hernando County in T23, R17E, S7 of the USGS Bayport Quadrangle. It was characteristic of the coastal region from Pasco County northward to the Big Bend area of Florida (Figure 4). Southward, this system is replaced by mangrove vegetation. Northward toward the Florida panhandle, this black needlerush marsh type is precluded by high-energy shorelines and occurs primarily along rivers and lagoons.

69. The uplands consisted primarily of slash pine flatwoods vegetation. It occurred on a thin veneer of sandy soil overlying limestone. These flatwoods were more xeric than is typical of flatwoods; the trees appeared stunted. Numerous solution cavities in the upland area often were occupied by trees or shrubs indicative of mesic to hydric habitats. Dominant species in the solution cavities included sweet bay, red maple, swamp red bay, and dahoon holly. Live oak, laurel oak, and southern magnolia were conspicuous as a sparse subcanopy.

70. The shrub layer was diverse in nature. Shrubs included beauty berry (*Callicarpa americana*), groundsel, and wax myrtle, in addition to the ubiquitous saw palmetto. The herb layer was composed of a diverse assemblage of grasses, sedges, composites, and legumes.

71. Cabbage palm was most abundant at the transition. The transition zone also was marked by an increased abundance of saw grass, switch grass (*Panicum virgatum*), leather fern (*Acrostichum danaeaefolium*), groundsel, and marsh-elder (*Iva frutescens*). Width of the zone varied from 0 to approximately 4 m.

72. The wetland was dominated by black needlerush, which provided about 90 percent cover. Lesser elements included saw grass, switch grass, and goldenrods (*Solidago* spp). This wetland area, irregularly flooded by tidal flow, represents a landward finger of an extensive brackish marsh system that extends north to the Gulf of Mexico.

Location of site boundaries and zones

73. In each wetland community, an area was chosen that was

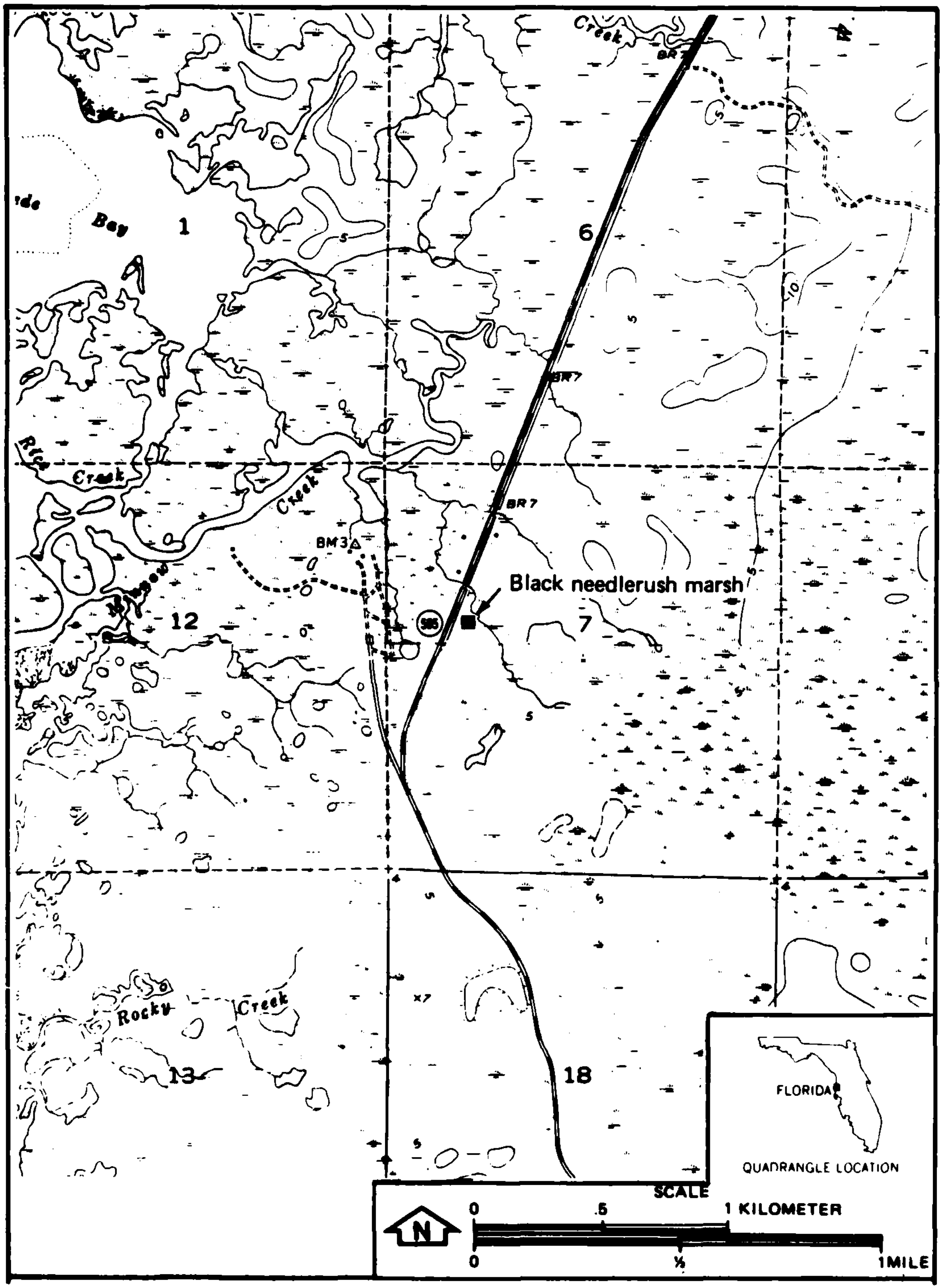

Figure 4. Location of saltwater marsh community (USGS, Bayport, Fla., 1954, and Aripeka, Fla., 1954)

relatively undisturbed, representative of the vegetation present, and reasonably homogeneous, except with regard to the changes along the moisture gradient. Sampling site sizes of at least 100 by 60 m for forested stands and 30 by 60 m for stands dominated by herbaceous vegetation were selected.

74. Suitable sites in this region were difficult to locate because of the size required for sampling sites. Many of the common wetland types, including cypress domes, marshes, and bayheads, are less than 4 ha. Most of these smaller wetlands are irregular or circular in shape. The shape and size of these wetlands affected the selection of sampling methods and limited the extent to which systematic sampling could be employed.

75. The width of each community was paced and a random numbers table used to locate transects by pacing from the starting point for a selected number of steps across the community (perpendicular to the moisture gradient). The transects were aligned parallel to the moisture gradient and marked with a 100-m tape. This tape served as one edge of the various-sized quadrats tested in each zone for each stratum. Thus, smaller quadrats were nested in larger quadrats so that differences between them would be due to different plot sizes rather than to random differences in plant distribution. The exception was in communities where the point-centered quarter method was used to sample trees. Shrub and herb plots were established using one of the quarter edges as a quadrat edge. The transects also served as an edge for the belt transects that extended from upland to wetland. Corners of quadrats were marked with stakes, and edges were marked with tapes while measurements were being recorded.

76. The upper and lower elevational limits of occurrence for several species were noted at each selected site as a step in delineating preliminary transition zone boundaries. Lower and upper limits of zones to be sampled were defined as follows.

a. Wetland--From a zone dominated entirely by hydrophytic species to the upper limit of a dominant wetland species.

b. Preliminary transition zone--Upper limit of a dominant

wetland species to lower limit of a dominant upland species.

c. Upland--Immediately upland of lower limit of a dominant upland species.

Results of field testing and evaluation

77. The sampling methods were ranked by the criteria thought to be most important in selecting the best method (Table 2). The highest-ranking method was accorded a value of 1, the second highest rank was given a value of 2, and so on. If two or more methods provided similar results, they were assigned the same rank.

78. The results from most methods for a particular stratum did not differ very much. The two exceptions were the 5- by 5-m quadrat for trees and the 2- by 1-m quadrat for shrubs; these quadrat sizes were clearly too small for the size scale of the particular life forms. Replicates rarely included the same species, and more units were required to achieve a leveling of the species-area curve or the SEM.

79. Belt transects were not ranked with the other methods in Table 2, since only species presence was recorded. Instead, the belt transect method was used for verification in conjunction with methods selected from Table 2 to determine whether information for quantitative sampling and frequency sampling could be combined. The contiguous quadrats of the belt allowed a more accurate delineation, and the quadrat and wandering quarter methods provided more reliable compositional data.

80. Trees. The 20- by 5-m quadrats were the most accurate, and replicates had the most similar species composition. However, this method had two serious disadvantages compared to the plotless point-centered quarter or its modification, the wandering quarter. The 20- by 5-m quadrats took twice as long to sample the same number of trees because of the time required to set up the plots. Moreover, they were not amenable to boundary delineations because the required 5-m width across the quadrat often exceeded the transition zone width. The number of trees counted in the plotless methods could be varied in accordance with the diversity encountered in the community sampled. It was usually

Table 2

Sampling Methods Ranked for Each Criterion Tested

Method	Rank Order: Accuracy of Species Importance*	Rank Order: Accuracy of Species Composition**	Rank Order: Sampling Sufficiency†
	Tree Stratum		
Point-centered quarter or wandering quarter	2	2	1
Plot sampling:			
5 m by 5 m	3	3	3
20 m by 5 m	1	1	2
	Shrub Stratum		
Plot sampling:			
4 m by 1 m	1	2	1
4 m by 4 m	1	1	2
8 m by 2 m	2	1	2
2 m by 2 m	2	3	2
2 m by 1 m	3	4	3
	Herb Stratum		
Plot sampling:			
1-m^2 circular	1	1	1
2 m by 1/2 m	1	1	1
1 m by 1 m	1	1	1

* Rank based on sum of differences from average importance obtained from all sampling methods.

** Rank based on percent of species shared by replicates.

† Rank based on number of replicates required to achieve asymptote for species area and SEM graphs multiplied by the time required to sample one replicate.

sufficient to count 60 to 80 trees. When the plot method was used, every tree in a quadrat had to be sampled for each replicate desired.

81. The wandering quarter method was chosen because it provided more complete coverage of a zone than the point-centered quarter method, which followed a straight line transect; moreover, there is no chance of counting a tree twice as there is in the latter method.

82. Shrubs. The 4- by 1-m and 4- by 4-m quadrats were the most accurate for determining species importance (Table 2). The 4- by 4-m and 8- by 2-m quadrats achieved sampling sufficiency with the smallest number of replicates and were the most floristically similar between replicates. The 2- by 2-m and 4- by 1-m quadrats were about equal in meeting this criterion. The time required for all methods differed very little since setting out the plots took 5 min and measuring specified importance ranged from 2 min for the smaller plots to 3 or 4 min for the larger plots. The 2- by 1-m quadrat was the lowest-ranking method for each criterion.

83. The 4- by 1-m and 8- by 2-m quadrats were chosen for the verification sampling. The larger quadrats were used for zones where vegetation was more patchy. Rectangles were chosen because the narrower width along the gradient allowed a finer tracking of gradient response than was provided by the width necessary for square quadrats of equal area.

84. Herbs. All of the quadrat shapes were equal in rank with regard to accuracy and sampling efficiency. Circular shape provided no advantage and was not considered for the verification phase. The use of circular plots precluded the nesting of larger shrub plots congruent to an edge marked by the tape measure; therefore, they also took longer to circumscribe. The 2- by 0.5-m quadrat shape was selected for the verification phase because it occupied a smaller segment (0.5 m) of the gradient than the 1- by 1-m shape.

85. Percent cover and frequency were the only vegetational parameters used to define composition of herbaceous species in the verification phase. Reasons for excluding stem counts were: counts took three times longer to complete; species differ in the number of aerial stems per individual plant; counts for species such as grasses are difficult;

and counts do not distinguish between small, stunted plants at the edge of a zone and large, vigorous individuals in the most favored part of a zone, whereas percent cover does. An IV was calculated by summing relative percent cover and relative frequency for each species.

86. Belt transects. The belt transects defined changes in species composition and importance. The occurrence of species along the transect was similar in the duplicate transects sampled within each community. Sampling was conducted at 1-m intervals along the gradient. The width tracked change closely, but did not provide an area large enough to obtain a valid estimate of importance for trees and shrubs. Frequencies in five consecutive 1-m quadrats were used to estimate species distribution. Combining frequencies eliminated many small, apparently random gaps in species distribution caused when a species occurred in one quadrat, skipped a succeeding quadrat, then occurred in several more. Chi-square tests were applied to presence-absence data to determine if significant species differences occurred among quadrats.

87. Species presence was noted regardless of the stratum in which it occurred. Combining strata provided more information for delineating vegetational zones, because many woody species occurred in two or three strata. Since presence of a species indicates a habitat favorable for growth, presence often conveys the same information regardless of the stratum in which it occurs; moreover, the presence of a tree species in a lower stratum indicates that regeneration is occurring, which is additional evidence that the habitat is favorable.

88. Sampling sufficiency. The species-area curves showed leveling at nearly the same number of units sampled as did the SEM of total density or cover (Table 3 and Figure 5). Although the theoretical basis for using SEM is stronger than that for species-area curves, both methods provide similar results. The species-area curve method is more convenient as a field guide because it can be graphed in the field without calculations.

Phase II: Verification of Methods

89. Sites and sampling methods selected for Phase II of the study

Table 3

Comparison of SEM and Species-Area Curves with Regard to Number of Replicates Required to Achieve Sampling Sufficiency*

Method	SEM Curve	Species-Area Curve	Difference**
		Number of Replicates Required	
	Tree Stratum		
Wandering quarter	8	6	2
Point-centered quarter	15	14	1
Plot sampling:			
5 m by 5 m	15	12	3
20 m by 5 m	5	4	1
	Shrub Stratum		
Plot sampling:			
4 m by 1 m	20	20	0
4 m by 1 m	25	15	10
8 m by 2 m	7	3	4
8 m by 2 m	12	12	0
2 m by 1 m	7	7	0
4 m by 4 m	10	10	0
2 m by 2 m	17	15	2
2 m by 2 m	15	14	1
4 m by 1 m	12	18	6
	Herb Stratum		
Plot sampling:			
2 m by 1/2 m	32	21	11
1 m by 1 m	32	30	2
1-m^2 circular	10	10	0
1 m by 1 m	10	7	3

* Representative samples of values for each stratum are shown. Each entry is from a different community.
** Number of units for SEM leveling minus the number of units for species-area leveling.

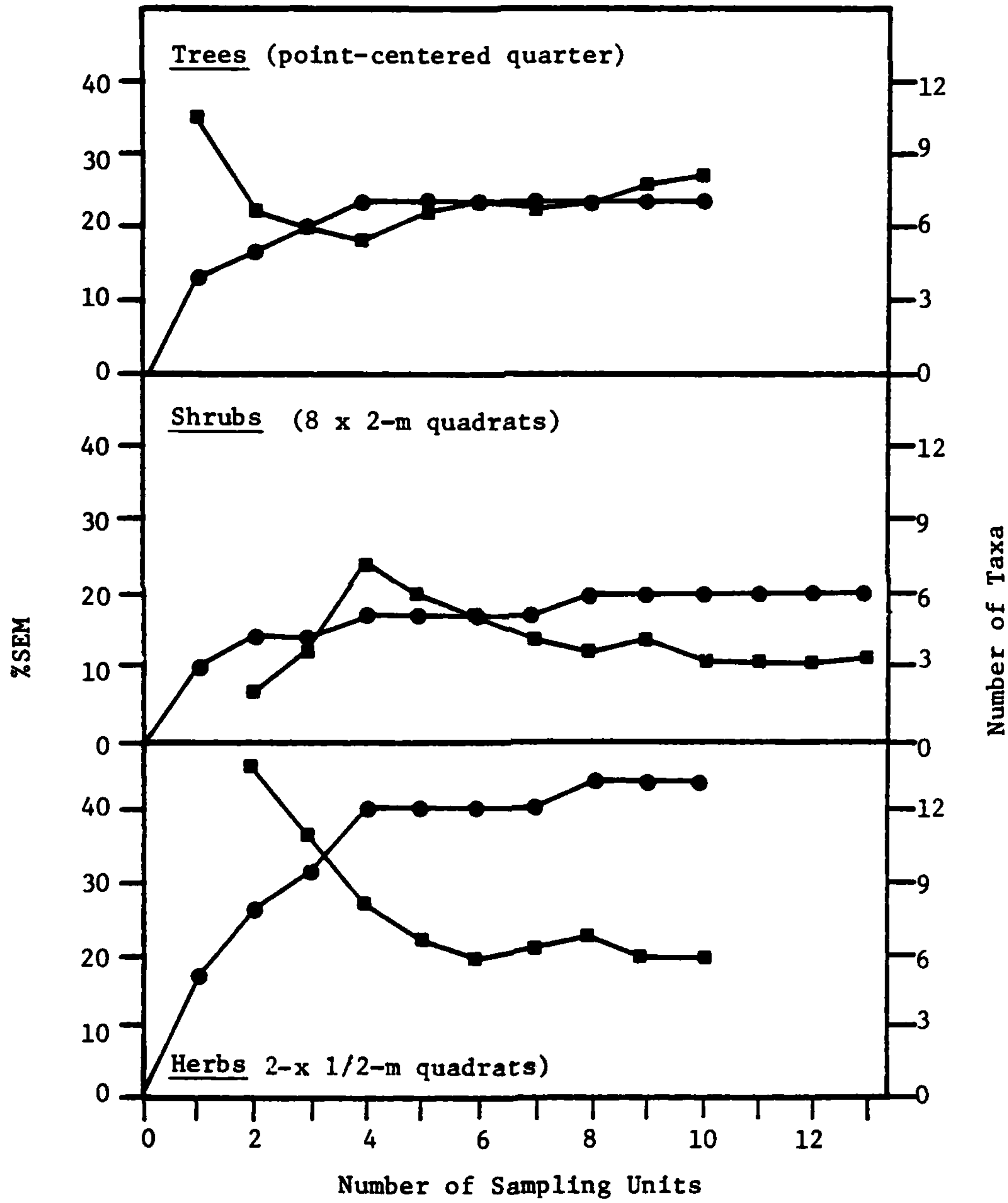

Figure 5. Representative shape of percent SEM curves (-●-) and species-area curves (-■-) (figures shown are from upland (pine flatwoods) zone of freshwater marsh site in Hillsborough River State Park)

are shown in Table 4. Locations of the sites are provided in Figures 6 through 8.

Description of study sites

90. Riverine cypress swamp and freshwater marsh (Morris Bridge well field). These sites are identified in Figure 6 (T27S, R20E, S34, USGS Thonotosassa quadrangle). Pine flatwoods occupied the upland areas adjacent to the swamp and marsh. The canopy was composed primarily of slash pine and smaller numbers of longleaf pine. The entire upland had been logged and burned; as a result, the canopy was open and trees were widely spaced. The uplands above the marsh were more open than the uplands above the swamp, resulting in a greater herbaceous diversity.

91. A dense shrub layer was composed primarily of saw palmetto with fewer numbers of dwarf live oak (*Quercus minima*), running oak (*Q. pumila*), chapman oak, myrtle oak, shiny blueberry (*Vaccinium myrsinites*), and wax myrtle. Herbs formed complete cover in patches, with wiregrass as the dominant herb.

92. Marsh. The transition zone of the marsh was abrupt. Slash pine and saw palmetto formed a distinct line between the uplands and the high-water levels in the marsh. The narrow transition zone was dominated by beak rushes, yellow-eyed grasses, wax myrtle, and goldenrods.

93. Two wetland zones were discernible within the marsh. A perimeter zone characterized by yellow-eyed grass (*Xyris ambigua*) and arrowhead (*Sagittaria graminea*) was evident. The remainder of the marsh was dominated by maidencane and pickerelweed. Floating aquatic herbs included floating hearts and frog's bit (*Limnobium spongia*) in the yellow-eyed grass/arrowhead zone and white water lily in deeper areas of the maidencane-pickerelweed area. Sphagnum moss (*Sphagnum macrophyllum* var. *floridanum*) was abundant in all areas, an unusual feature for marshes in Florida.*

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* The occurrence of *Sphagnum macrophyllum* var. *floridanum* is a record for Hillsborough County. Species identification was performed by Dr. Diane TeStrake Wagner-Merner, Associate Professor, Department of Biology, University of South Florida.

Table 4

Sites and Methods Selected for Verification Phase

Wetland	Location	Sampling Methods, Number of Replicates, and Zone Tested for: Tree	Shrub	Herb
Riverine cypress swamp	Morris Bridge well field near Hillsborough River, Hillsborough County	WTU: 75 WQ**	W: 15 ea 8 × 2 T: 10 ea 8 × 2 U: 15 ea 4 × 1	WTU: 15 ea 2 × 1/2
Freshwater marsh	Morris Bridge well field	WTU: 75 WQ	WT: 10 ea 8 × 2 U: 15 ea 4 × 1	W: 20 ea 2 × 1/2 TU: 15 ea 2 × 1/2
Bayhead swamp	52nd Street, one block south of Fowler Avenue, Tampa, Hillsborough County	WTU: 75 WQ	WTU: 15 ea 4 × 1	WTU: 15 ea 2 × 1/2
Mangrove swamp	Honeymoon Island, North Pinellas County	WTU: 75 WQ	WTU: 15 ea 4 × 1	W: 30 ea 2 × 1/2 TU: 15 ea 2 × 1/2

* At least two belt transects were sampled for each community.

** W = wetland zone.
T = transition zone.
U = upland zone.
WQ = wandering quarter.

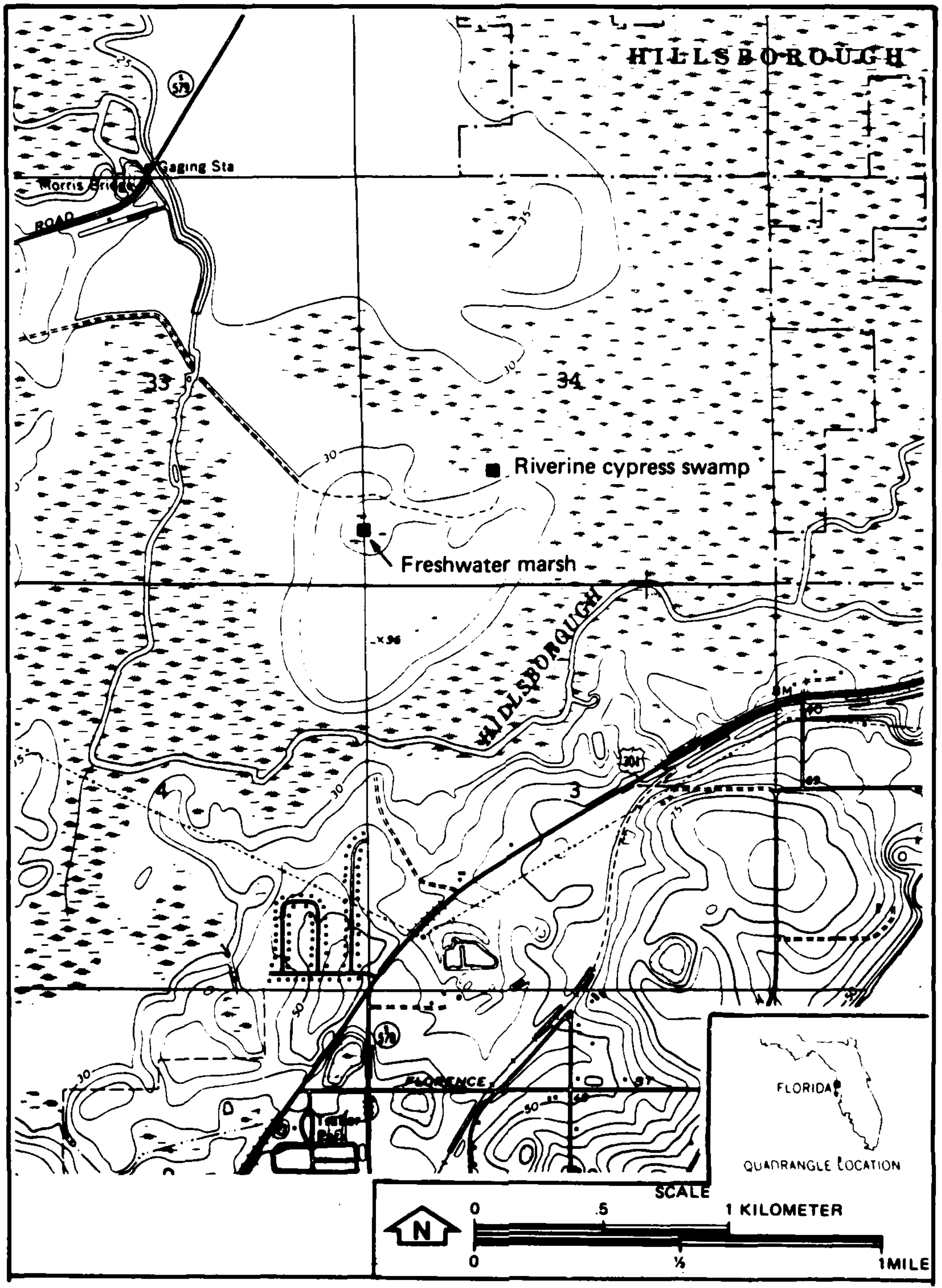


Figure 6. Locations of Morris Bridge freshwater marsh and riverine cypress swamp (USGS, Thonotosassa, Fla., 1974)

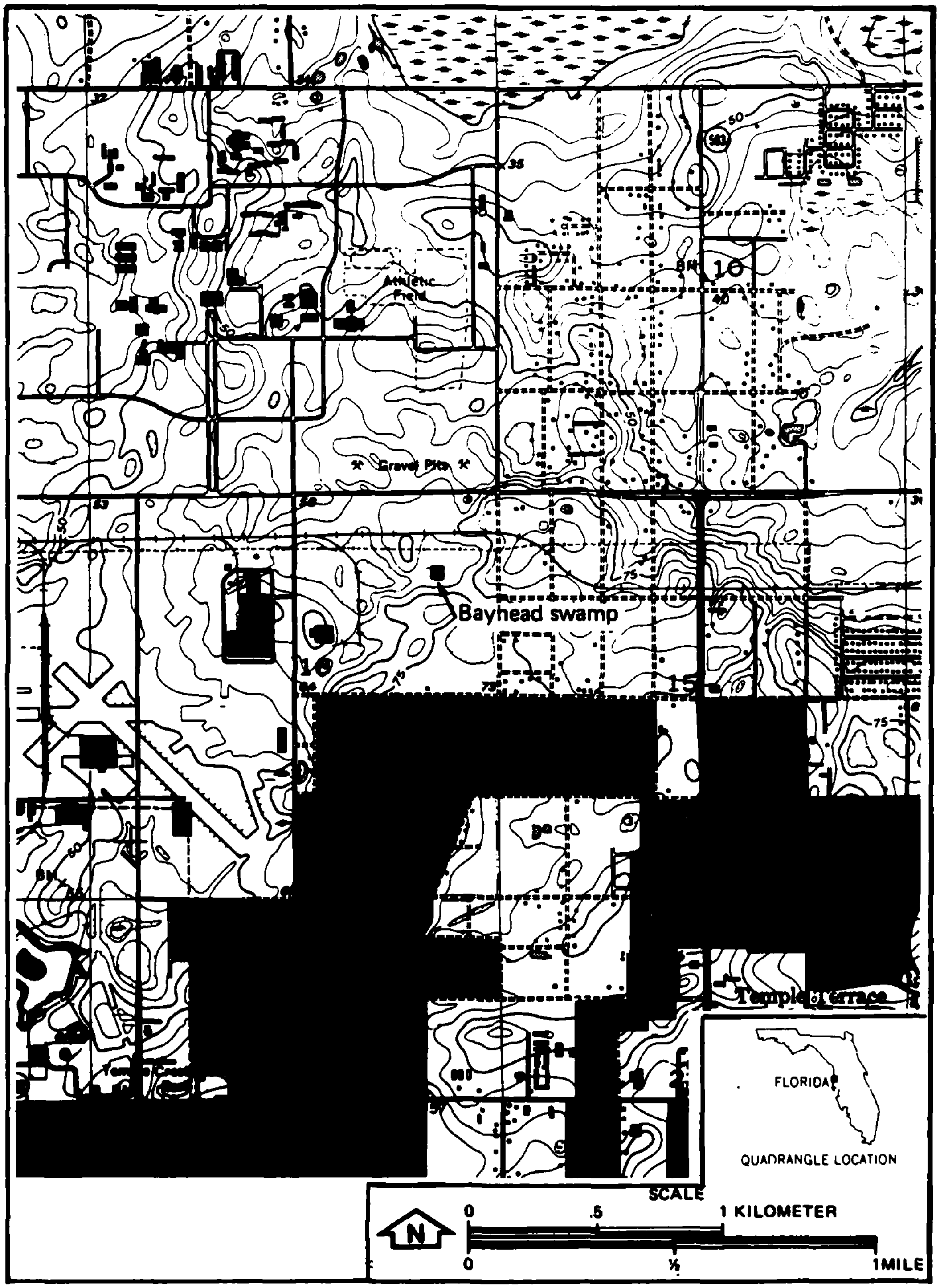


Figure 7. Location of bayhead swamp (USGS, Sulphur Springs, Fla., rev. 1969)

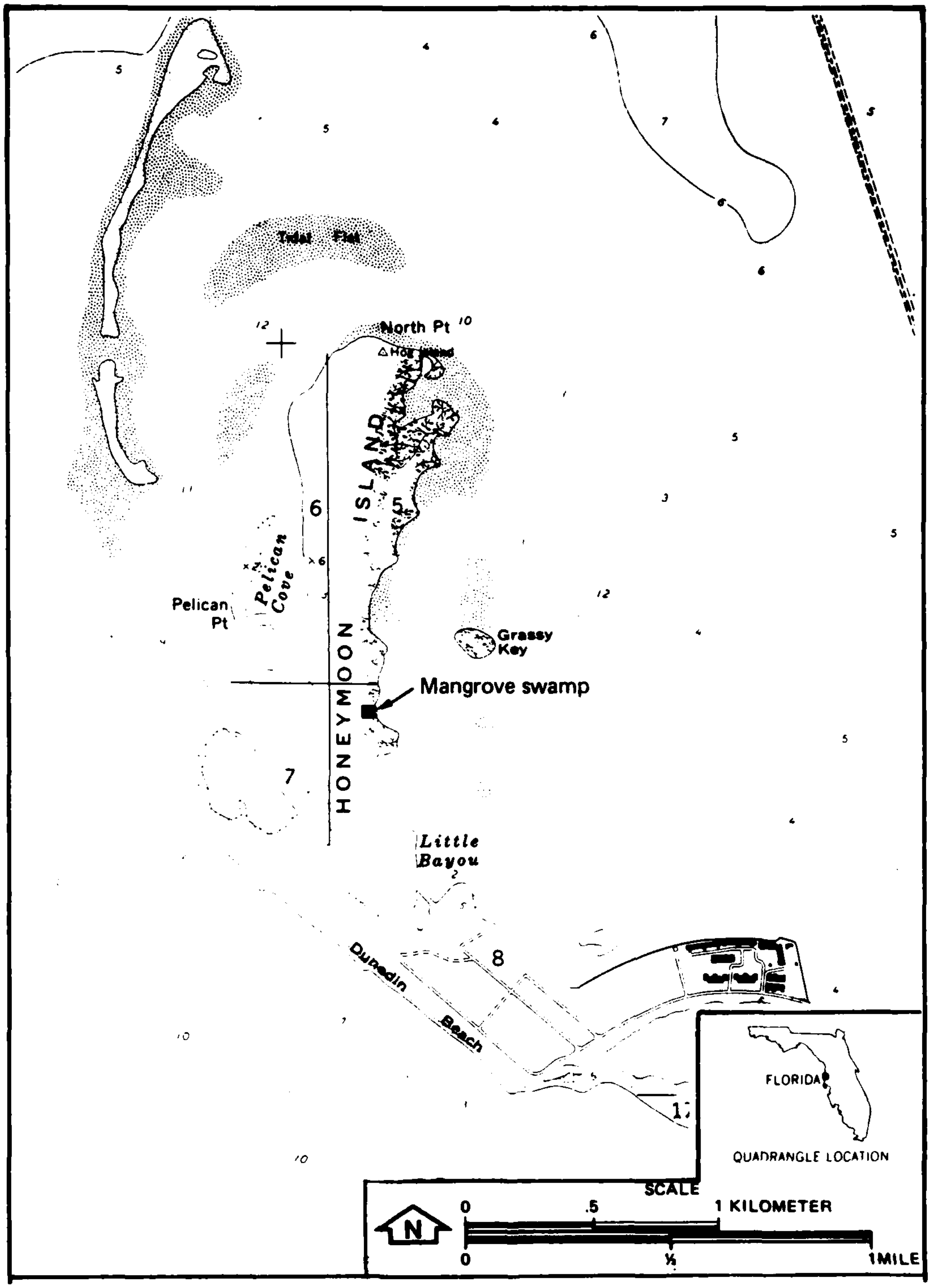


Figure 8. Location of mangrove swamp (USGS, Dunedin, Fla., 1974)

94. <u>Riverine cypress swamp.</u> The transition in the canopy level from pineland to the riverine hardwood swamp was broad. Near the upland, a dense canopy was dominated by laurel oak and cabbage palm. Florida elm was infrequent. Toward the swamp edge, swamp tupelo, bald cypress, and occasionally red maple became more abundant.

95. Shrubs were scattered throughout and included wax myrtle, groundsel (*Baccharis glomeruliflora*), wild coffee (*Psychotria nervosa* and *P. sulzneri*), and black haw (*Viburnum obovatum*).

96. Herbs were patchy in distribution. Bracken fern (*Pteridium aquilinum*), partridge berry (*Mitchella repens*), and panic grasses (*Panicum anceps*, *Panicum agrostoides*) were common herbs.

97. The canopy in the swamp was dominated by swamp tupelo and bald cypress. Water ash formed a distinct subcanopy. Terrestrial herbs were common only at the bases of trees and included milkweed (*Asclepias perennis*), swamp fern, bugleweed (*Lycopus rubellus*), and false nettle (*Boehmeria cylindrica*). Pickerelweed, horned rush, and sawgrass were the most common emergents. Standing water was evident throughout the swamp.

98. <u>Bayhead swamp (off Fowler Avenue).</u> In this area (T28S, R15E, S16, USGS Sulphur Springs quadrangle), the upland was a longleaf pine-turkey oak sandhill. The transition from sandhill to bayhead was gradual and herb-dominated. The canopy was composed of scattered individuals of longleaf pine and turkey oak, though many of the trees had been cut out. The dense shrub layer was dominated by dwarf live oak, chapman oak, myrtle oak, and saw palmetto. A diverse assemblage of herbs occurred in open areas. Wiregrass was dominant, and other herbs included beard-grasses, milkpeas (*Galactia* spp.), *Balduina angustifolia*, sunflower (*Helianthus simulans*), *Chapmannia floridana*, blazing stars (*Liatris* spp.), goldenrods, and deer's tongues (*Carphephorus* spp).

99. The wetland consisted of a circular bayhead community occupying a raised, peaty substrate and a shallow pool in the center. The canopy of the bayhead was closed and included loblolly bay, sweet bay, swamp red bay, and dahoon holly. A well-defined shrub layer consisting primarily of wax myrtle and swamp blueberry (*Vaccinium corymbosum*) was evident.

Herbs were sparse. Beak rushes, swamp fern, and Virginia chain fern (*Woodwardia virginica*) were most common. The pool in the center was approximately 0.5 m deep. The bottom was covered by creeping rush (*Juncus repens*).

100. Mangrove swamp (Honeymoon Island, Pinellas County). The uplands at this site (T28S, R15E, S8, USGS Dunedin quadrangle) are flatwoods dominated by southern slash pine (*Pinus elliottii* var. *densa*). A dense shrub layer included young cabbage palm, wax myrtle, groundsel, Spanish bayonet (*Yucca aloifolia*), and saw palmetto. The herb layer forms 100-percent cover in open areas and is characterized by wiregrass, St. Augustine grass (*Stenotaphrum secundatum*), and Spanish needles (*Bidens pilosa*). Poison ivy (*Toxicodendron radicans*) and muscadine grape form thickets in disturbed areas. The soil is sandy, and the site is xeric in aspect.

101. The transition zone is generally wide. Some portions are dominated by salt pan vegetation, others by a shrub-herb assemblage. St. Augustine grass, salt grass (*Distichlis spicata*), aster (*Aster subulatus*), and sea purslane (*Sesuvium portulacastrum*) dominated herbaceous areas of the transition zone. White mangrove seedlings were common in open areas.

102. The wetland was dominated by mangrove vegetation forming a dense stand. Landward, buttonwood and white mangrove were the dominant trees. Toward the intracoastal waterway, white mangrove and black mangrove became abundant. Red mangrove fringed the water's edge. Leather fern was the only common herb.

Species composition and distribution in communities

103. Scientific and common names are shown in Appendix A, Table A1. A complete list of all species encountered, together with the communities and zones in which each species was found, is presented in Appendix A, Table A2.

104. Appendix Tables B1-B4 and C1-C4 show the distribution of IVs of the most important species in the three subjectively delineated zones for the eight communities sampled in both Phase I and Phase II,

respectively, of the study. Values shown for the Phase I communities were those obtained from the sampling methods judged to be the most appropriate; i.e., the methods used in Phase II.

105. Only the species that had a frequency of at least 20 percent in one of the three zones were included in these tables. Species occurring less often were considered too erratic or uncommon to yield much information about community changes along the gradient.

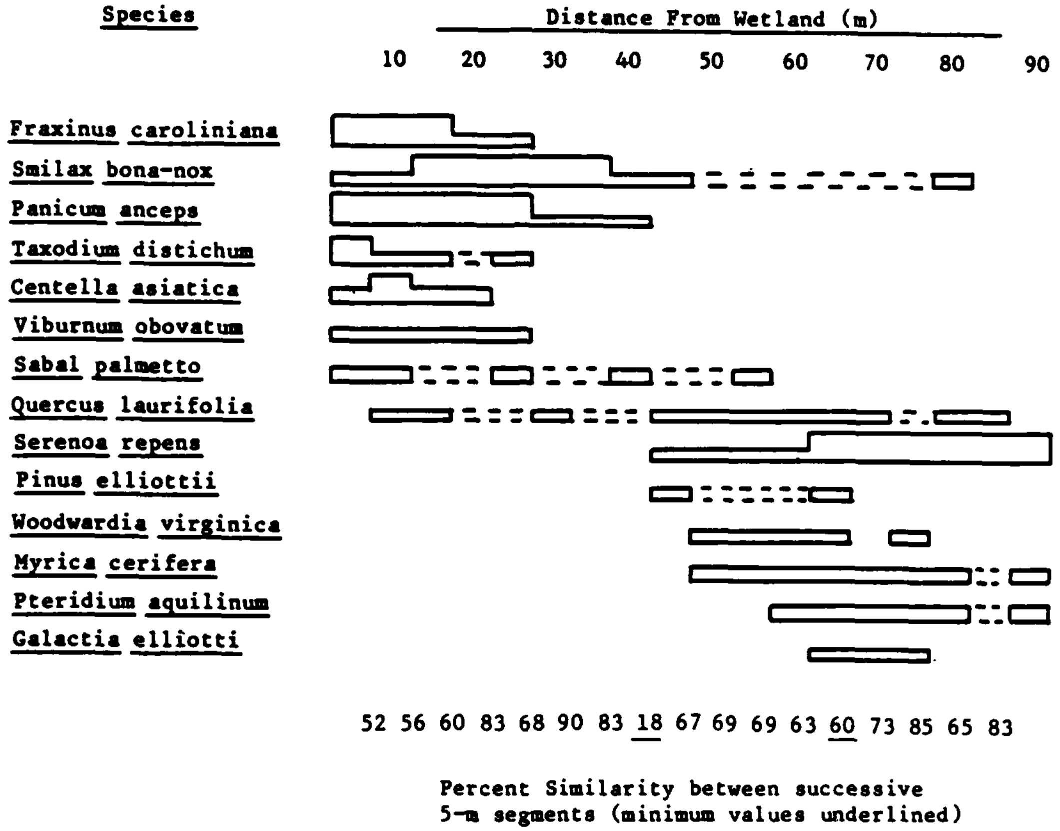
PART III: PHASE II STUDY--DELINEATION OF WETLANDS TRANSITION ZONES

Delineation Methods

106. Figures 9 through 16 illustrate the distributions of species with frequencies of 20 percent or greater, based on the belt transect data from eight Phase I and Phase II sites. The belt transects extended from a point within the wetland to a point in the upland. The graphs illustrate the independent nature of the species distribution within and among the sites in a pattern which, as Webb (cited in Greig-Smith 1964) described, "...hovers in a tantalizing manner between the continuous and the discontinuous." It was assumed that each species exhibits a normal distribution (except where truncated at an upland or wetland endpoint) over some portion of the gradient. The centers of the distributions are scattered along the gradient; species importance and distribution over the gradient also differ. Three methods representing different approaches for analyzing these species distributions were used for preparing delineations of the transition zone boundaries.

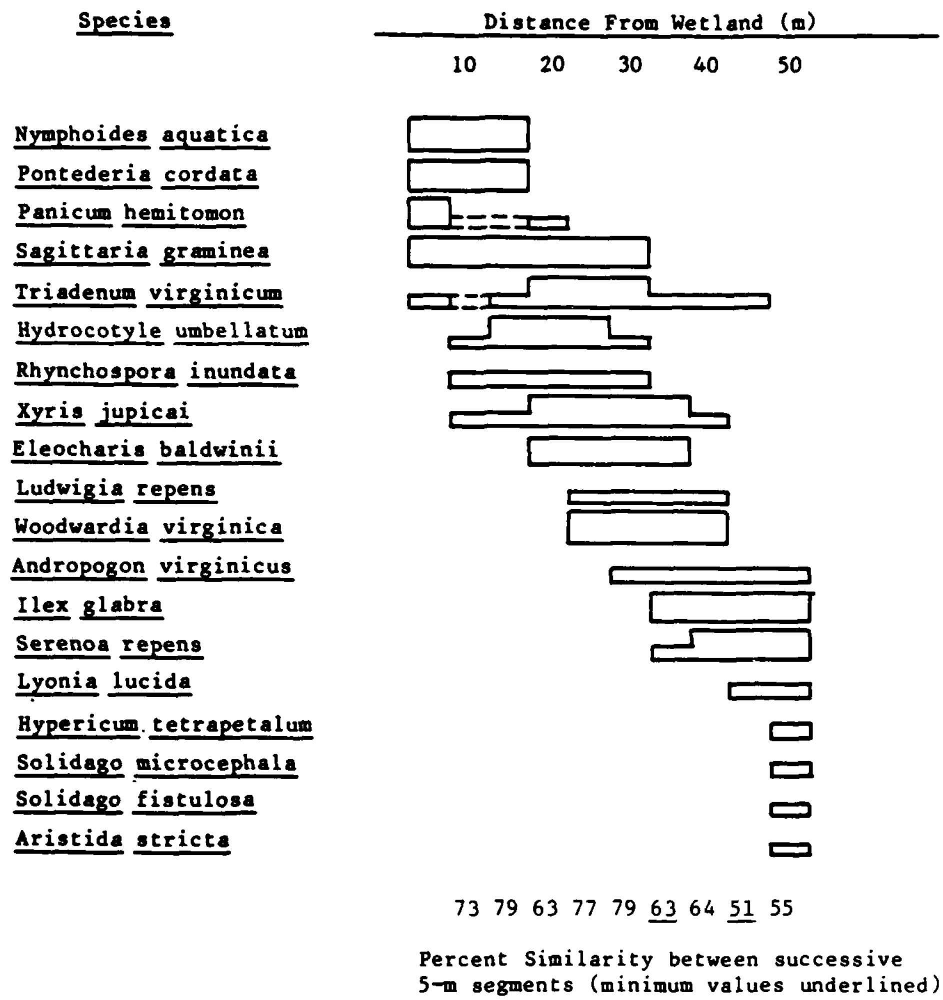
Method I. Percent similarity of successive segments of the gradient

107. The similarity of species composition between two samples can be measured by calculating an index of similarity (Mueller-Dombois and Ellenberg 1974). An index of similarity of two successive samples along an environmental gradient provides a quantitative measure of the change in species composition in that segment of the gradient. A comparison of successive index of similarity values along the gradient shows how rapidly the change in composition is occurring at any segment on the gradient. The segment where change is most rapid could be interpreted as the location of a community boundary. Method I uses an index, PS, to measure species change (Whittaker 1978, Gauch and Whittaker 1972). It is the percentage of species shared by two samples and is given by:



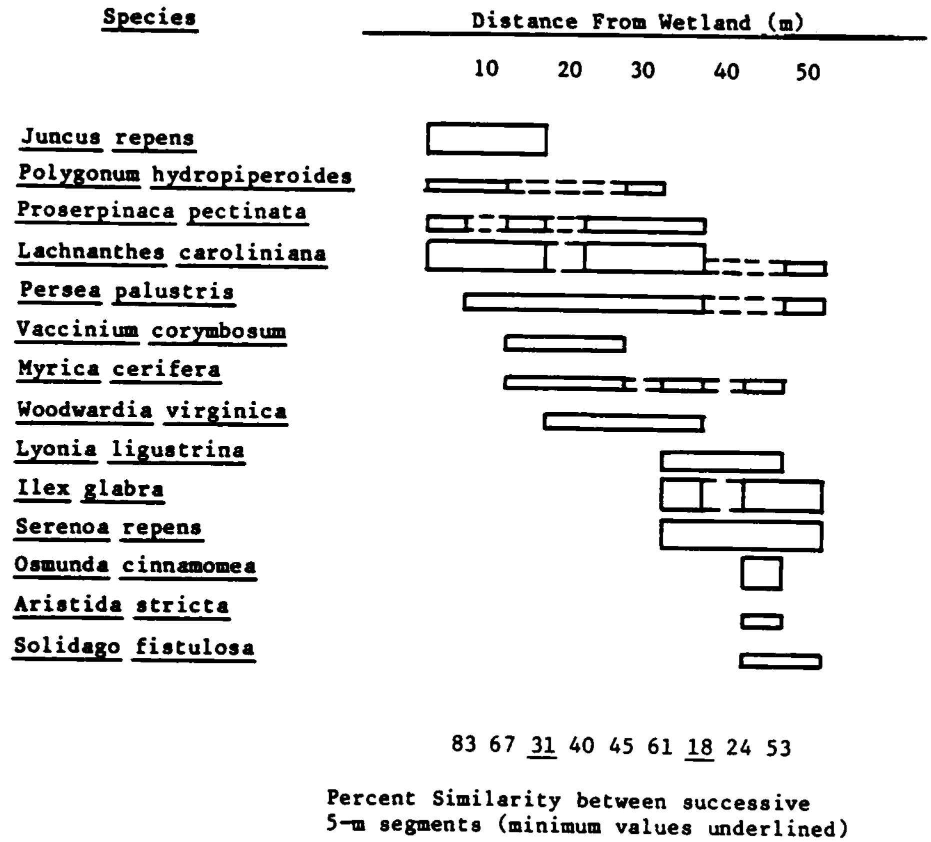
Legend: Larger height of bar indicates greater than 50-percent frequency in 5-m segment. Dashed lines represent discontinuities in occurrence from wetland endpoint sample to upland endpoint sample of belt transects. Underlined percent similarity values indicate transition zone boundaries using Method I.

Figure 9. Distribution of species along a moisture gradient from wetland to upland in Morris Bridge riverine cypress swamp community (larger height of bar indicates greater than 50 percent frequency in 5-m segment; dashed lines represent discontinuities in occurrence from wetland endpoint sample to upland endpoint sample of belt transects; underlined percent similarity values indicate transition zone boundaries using Method I)



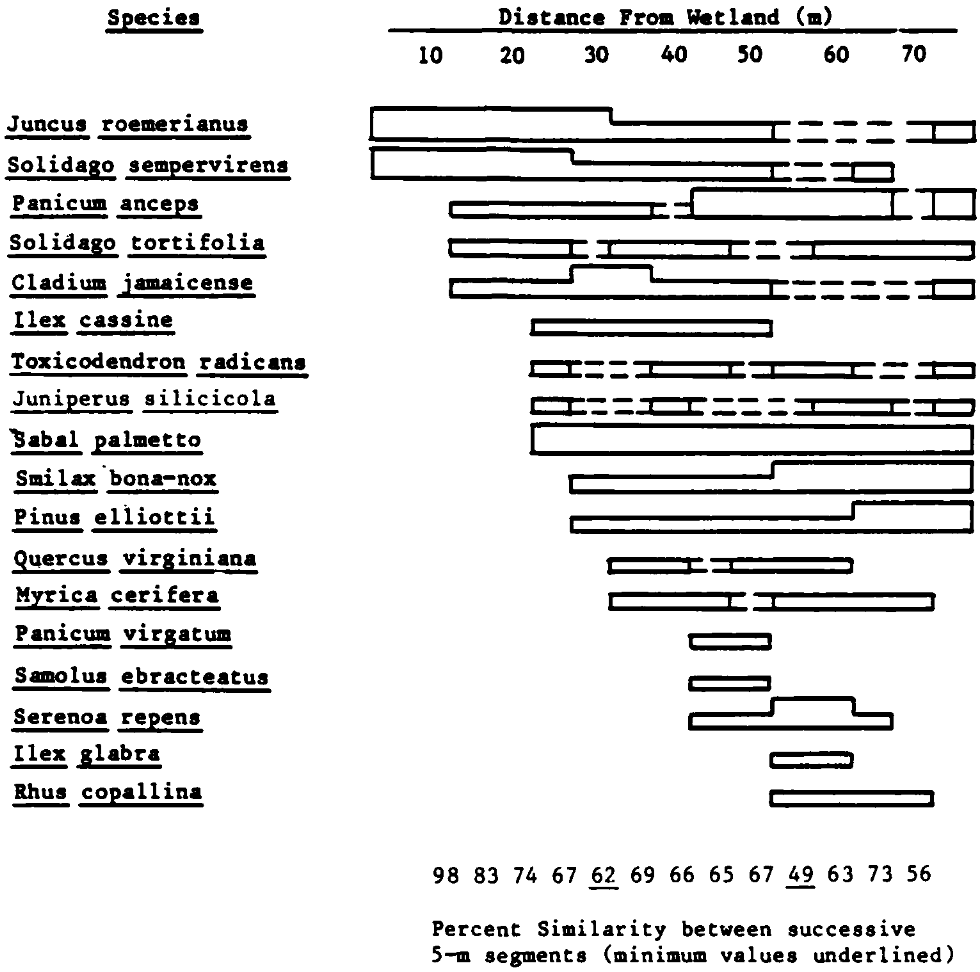
(See Legend, Figure 9)

Figure 10. Distribution of species along a moisture gradient from wetland to upland in Morris Bridge freshwater marsh community (larger height of bar indicates greater than 50 percent frequency in 5-m segment; dashed lines represent discontinuities in occurrence from wetland endpoint sample to upland endpoint sample of belt transects; underlined percent similarity values indicate transition zone boundaries using Method I)



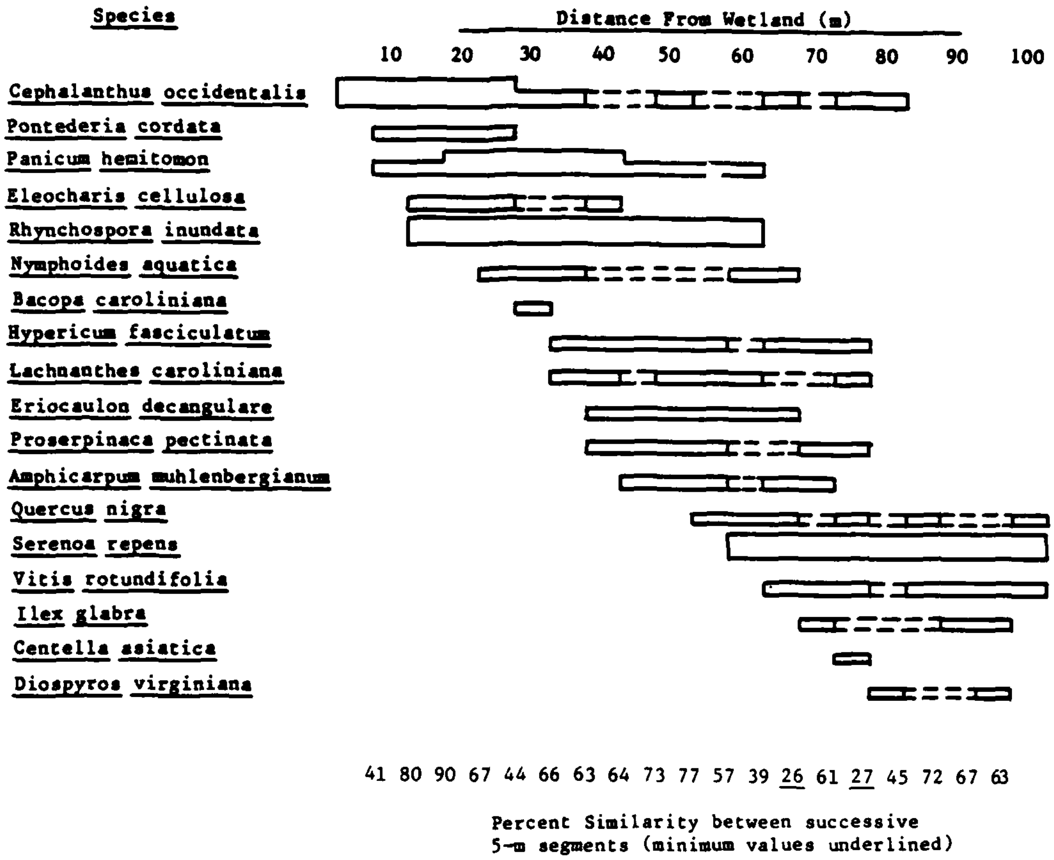
(See Legend, Figure 9)

Figure 11. Distribution of species along a moisture gradient from wetland to upland in bayhead freshwater marsh community (larger height of bar indicates greater than 50 percent frequency in 5-m segment; dashed lines represent discontinuities in occurrence from wetland endpoint sample to upland endpoint sample of belt transects; underlined percent similarity values indicate transition zone boundaries using Method I)



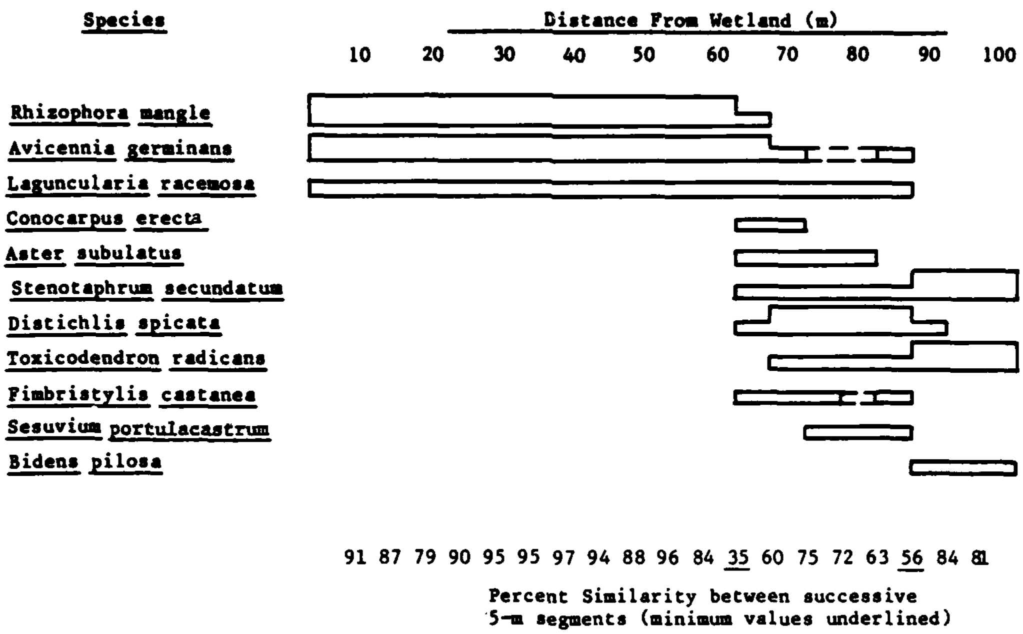
(See Legend, Figure 9)

Figure 12. Distribution of species along a moisture gradient from wetland to upland in salt marsh community (larger height of bar indicates greater than 50 percent frequency in 5-m segment; dashed lines represent discontinuities in occurrence from wetland endpoint sample to upland endpoint sample of belt transects; underlined percent similarity values indicate zone boundaries using Method I)



(See Legend, Figure 9)

Figure 13. Distribution of species along a moisture gradient from wetland to upland in Hillsborough River freshwater marsh community (larger height of bar indicates greater than 50 percent frequency in 5-m segment; dashed lines represent discontinuities in occurrence from wetland endpoint sample to upland endpoint sample of belt transects; underlined percent similarity values indicate transition zone boundaries using Method I)



(See Legend, Figure 9)

Figure 14. Distribution of species along a moisture gradient from wetland to upland in mangrove swamp community (larger height of bar indicates greater than 50 percent frequency in 5-m segment; dashed lines represent discontinuities in occurrence from wetland endpoint sample to upland endpoint sample of belt transects. Underlined percent similarity values indicate transition zone boundaries using Method I)

$$PS = \sum_{i=1}^{n} \min(Pij, Pik)$$

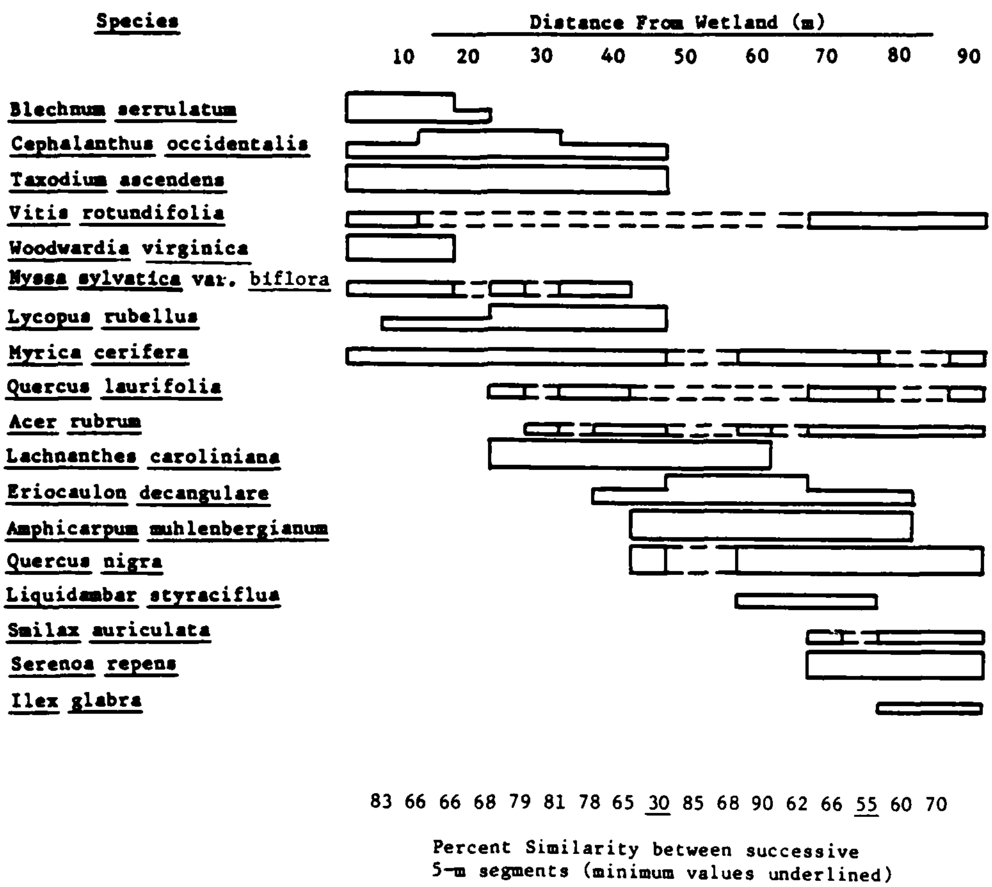
where

Pij and Pik = the relative values for species importance (i) in samples (j) and (k) in the two samples compared

n = the number of species common to both samples

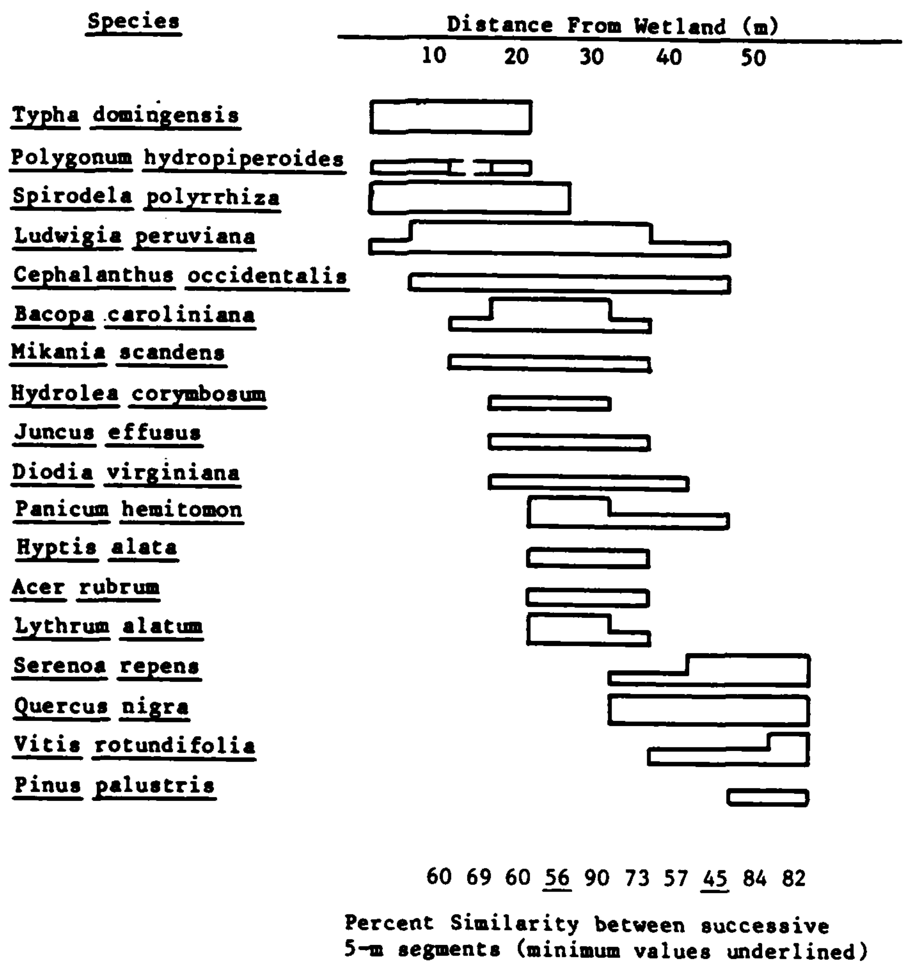
min = the lower of the two values being compared for each species

108. The selected measure of species importance should be a sensitive indicator of a species' adaptation to existing environmental



(See Legend, Figure 9)

Figure 15. Distribution of species along a moisture gradient from wetland to upland in Hillsborough river cypress community (larger height of bar indicates greater than 50 percent frequency in 5-m segment; dashed lines represent discontinuities in occurrence from wetland endpoint sample to upland endpoint sample of belt transects; underlined percent similarity values indicate transition zone boundaries using Method I)



(See Legend, Figure 9)

Figure 16. Distribution of species along a moisture gradient from wetland to upland in Hillsborough River shrub swamp community (larger height of bar indicates greater than 50 percent frequency in 5-m segment; dashed lines represent discontinuities in occurrence from wetland endpoint sample to upland endpoint sample of belt transects; underlined percent similarity values indicate transition zone boundaries using Method I)

conditions. It is converted to a relative value because its importance in comparison with other species present in the sample is desired. It could be a composite index such as importance value, percent cover, or some scaled, standardized, or transformed form of the original parameter measured. Different treatments of the data weigh the contribution of each species differently (van der Maarel 1969), and the abundance measure should be carefully chosen in accordance with the purposes of the study.

109. The value of species importance used in this study was frequency in the ten 1-m-wide quadrats of each 5-m segment of duplicate belt transects. Frequency was selected to give each species equal weight; percent cover or IV gives more weight to large, leafy, and heavily branched species. Since the response of every species, large or small, to the gradient is equally important in determining boundaries, frequency is a more useful measure.

110. The PS values between successive 5-m segments of the transects were calculated to determine the location of minimum PS values compared to the adjacent PS values. The positions of these minimum values of the transects can be used to delineate boundaries separating transition zones from uplands and wetlands.

111. Successive PS values between 5-m segments of the transects in the communities studied are shown in Figures 9 through 16. PS minima also occur within wetlands and uplands because gradients exist within these communities as well as between them. To choose the minima that best represent transition boundaries, certain restrictions must be placed on the selection of transects and on the location of baselines or endpoints for these transects.

112. First, the upland endpoint that is sampled must be that portion of the upland closest to the transition zone or zone of contention with regard to the wetland definition. Selection of this zone does not involve prejudging the transition-upland zone boundary, but only the identification of an unambiguous upland area, based on the vegetation. The first PS minimum encountered below this zone, where PS values are higher on each side, is then designated the upland-transition zone

boundary. If a PS minimum value is due to some obvious vegetational change based on a factor other than the moisture gradient (for example, a clearing or rock outcrop), a boundary should not be designated at this point of change.

113. Following the gradient toward the wetland from the upland-transition boundary, the next interval with a minimum PS value relative to those of adjacent segments represents the boundary between the transitional zone and the wetland. Any minimum values which appear between this boundary and the wetland endpoint are considered to indicate boundaries of zones within wetlands.

Method II. Weighted averages

114. Natural clusters of species along environmental gradients can be revealed by the use of species-WA (Whittaker 1960). These are obtained by multiplying the selected vegetational parameter of a species by an index of its mean position on the gradient. If the WAs of species are plotted on a metric representation of the transect, the distances between the WAs should indicate the extent of the ecological differences between them. If some species cluster at certain locations, these locations may represent different ecological zones along the gradient. The edges of the clusters indicate zonal boundaries.

115. In this study, the gradient represents a complex variable composed of frequency, duration, depth of flooding, and distance to water table. Its length is the distance from the most saturated zone sampled to the upland. Equal metric distances are unlikely to represent equal intensities of the real variables (i.e., linear relationship), but there should be some correlation between metric distance and ecological distance. The distance from the wetland endpoint of the species' location on the transect represents its environmental position.

116. Weighted average for a species is calculated as follows:

$$WA = \frac{\Sigma(D \cdot RF)}{\Sigma RF}$$

where

D = distance of the 5-m segment of the belt transect from the wetland endpoint

RF = relative frequency of that species within each segment

117. In this calculation, the relative frequency of the species within each segment is multiplied by the distance of the segment from the endpoint. These values for all segments in which the species occurs are then summed and divided by the sum of the relative frequencies of that species in the segments. The resultant weighted average represents the location of the center of distribution of the species along the gradient. It represents an approximation of the midpoint of a normal curve.

118. The weighted average is expressed as a distance from the endpoint of the gradient. For example, a wetland species may have a relative frequency (RF) of 100 in the 5-m segment nearest the wetland end of the transect and an RF of 50 at 10 m from the wetland end. Its WA would be $(100 \times 5) + (50 \times 10)/150$, or 6.7. A transition species might have a relative frequency of 50 at 30 m from the wetland, a relative frequency of 50 at 35 m, and a relative frequency of 10 at 40 m. Its WA would be $(50 \times 30) + (50 \times 35) + (10 \times 40)/110$, or 33.2. These weighted averages are plotted on a line representing the gradient. Groups of species whose mean distance apart is closer than the distance between groups represent distinct zones along the gradient.

119. This method is similar to reciprocal averaging (Hill 1973), a computer method for ordinating species, which has been used for indirect ordination when the location of the environmental gradient within an area is unknown. It is an iterative process in which species are first weighted by positions along a subjectively chosen initial gradient and the weights used to calculate sample scores. The sample scores are used to recalculate species-weighted averages and so on until a stable optimal solution is reached that is independent of the initial species positions. There are other computer-based methods to determine boundary locations that could be used in addition to the simple methods selected for this study.

120. Such computer-based methods have been used by Hume and Day (1972) on presence-absence data to study beta diversity. Pielou (1977) recorded the presence of locations of upper and lower boundaries of species on transects parallel to a gradient to determine by computer

ordination if there were points where the number of species boundaries was higher than would be expected by chance and which therefore denoted a zonal boundary.

Method III. Subjective delineation of boundaries

121. The quantitative quadrat sampling program was based on subjective delineation of zones (see Part II) by field personnel. Zone boundaries were identified as locations in which a distinct change ir species occurrence could be observed. The location of subjectively delineated zones could be estimated by comparing species composition in the quantitative sampling units with the belt transect data to determine where on the gradient the quantitative sampling occurred.

Phase II: Results

122. In this discussion of results, all three methods were compared by determining which gave the least ambiguous resolution of boundaries and which resulted in boundaries that were biologically acceptable.

Method I. Percent similarity of successive segments of the gradient

123. PS values are presented along with species distribution for all eight communities (Figures 9 through 16) so that the location of PS minima can be referenced to the species' distributions. Ideally, there should be some way of determining that PS minima are significantly lower than other PS values within the zones so delineated. However, the distribution of PS values is complex and not represented by a normal curve, so parametric statistical analyses are not appropriate. Monte Carlo computer simulations have been recommended for statistical analyses of similarity indices (Ricklefs and Lau 1980); however, such techniques are complex, require sophisticated equipment, and are beyond the resources of most personnel who will be evaluating transition zones.

124. Table 5 shows the mean PS values for all adjacent pairs within the defined wetland, transition zone, and upland. The range of such values found within each zone is shown below the mean value. The

Table 5

Mean Percent Similarity (PS) Values Within Zones, Range of PS Values Within Zones, and the Minimum PS Values (Interzone Values) Which Mark the Boundaries Between Wetland, Transition, and Upland Zones

Site	Zone				
	Wetland Zone PS	Wetland-Transition Interzone* PS	Transition Zone PS	Transition-Upland Interzone** PS	Upland Zone PS
Saltmarsh	80.5 67-98	62	67 65-69	49	64.0 56-73
Morris Bridge marsh	76 63-79	63	64(1)	51	55(1)
Hillsborough River marsh	63 39-90	26	61(1)	27	62 45-72
Mangrove swamp	91 79-97	35	68 60-75	56	83.5 81-84
Hillsborough shrub swamp	63 60-69	56	73 57-90	45	83 82-84
Bayhead swamp	75 67-83	31	48 40-61	18	39 24-53
Hillsborough cypress swamp	73 65-83	30	74 62-90	55	65 60-70
Morris Bridge cypress swamp	68 52-90	18	67 63-69	60	76.5 65-85

* The wetland-transition interzone is the position along the gradient at which the boundary occurs between obvious wetland and the transition zone.

** The transition-upland interzone is the position along the gradient at which the boundary occurs between the transition zone and obvious uplands.

minimum PS values used to define the lower and upper boundaries of the transition zone are shown as the interzone PS values. This table shows that, in most cases, the minimum PS values are well below the range of values that occur within a zone.

125. In the Hillsborough River cypress swamp, the minimum PS value of 62 (see Figure 15) was so close to the zonal mean PS value of 65 that it was rejected as a boundary in favor of a lower (closer to the wetland endpoint) boundary with a minimum PS of 30 to mark the wetland-transition zone boundary.

126. The within-zone mean PS values ranged from 63 to 91 for wetlands, 48 to 74 for transition zones, and 39 to 83 for uplands. Minimum PS values marking boundary zones ranged from 18 to 63 for the wetland boundaries and 18 to 60 for the upland boundaries.

Method II. Weighted averages

127. The weighted average for each species was plotted on a line representing the distances of the 5-m segments from the wetland endpoint (Figures 17-20). In some communities, species groups represented by aggregations of weighted averages are quite distinct (Hillsborough River freshwater marsh); in other communities (Morris Bridge cypress swamp), they are not as clearly distinguished by visual inspection.

128. Boundaries were delineated by identifying species groups; i.e., species whose mean distances from each other are shorter than the distance between groups. For example, the central positions of the most upland group in the bayhead swamp ranged from 39.5 to 48 m. The mean distance between all species in the group was 3.9 ± 0.69 m (SEM). The distance from the lowest (closest to the wetland endpoint) species in this group to its nearest neighbor of the next group was 10 m, a span that exceeded any distance between species within the group. Therefore, the transition-upland boundary was chosen as the point just below the central position (weighted average) of the lowest species of the most upland group. For the bayhead swamp, this point is 35 m from the wetland endpoint.

129. The lower groups in the bayhead swamp were not so well defined as the upland group. The next two species below the upland group

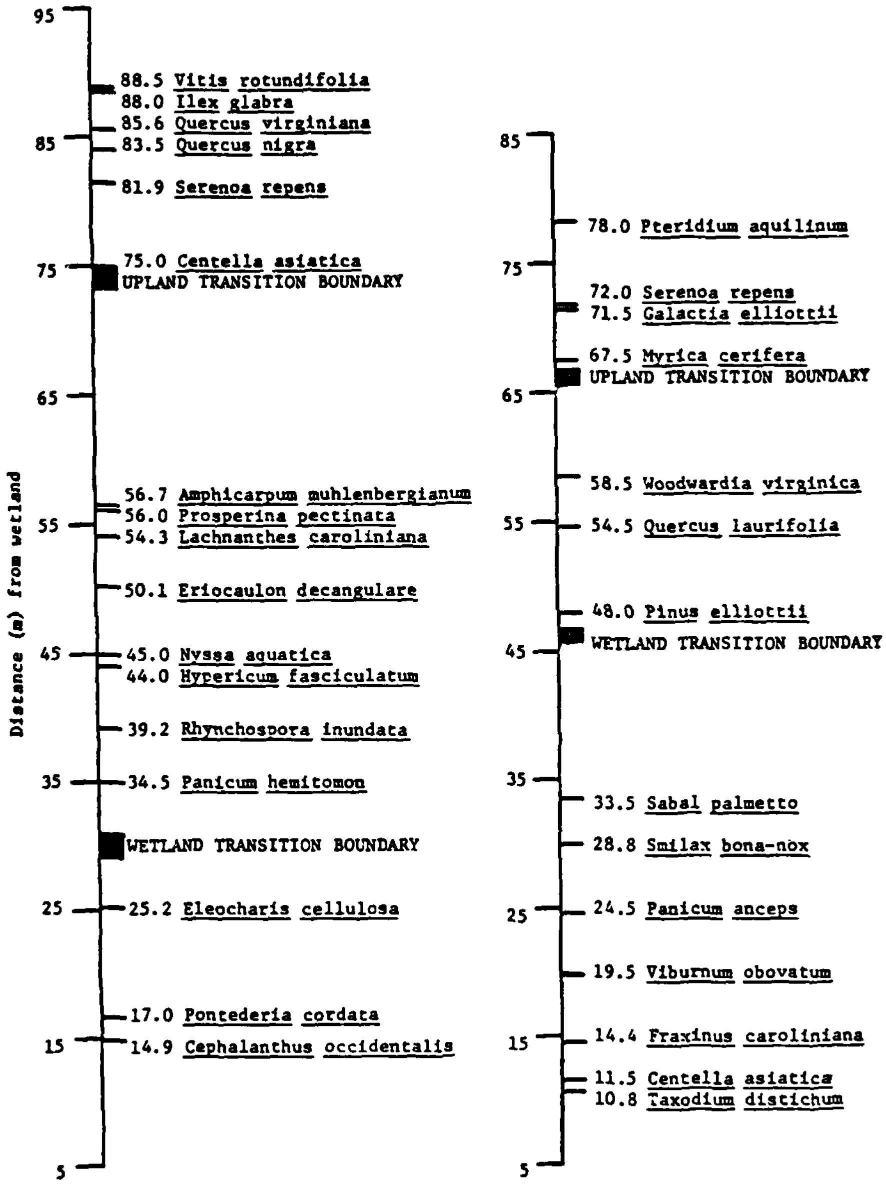


Figure 17. Weighted averages of species along wetland-upland gradient, Hillsborough freshwater marsh and Morris Bridge cypress swamp

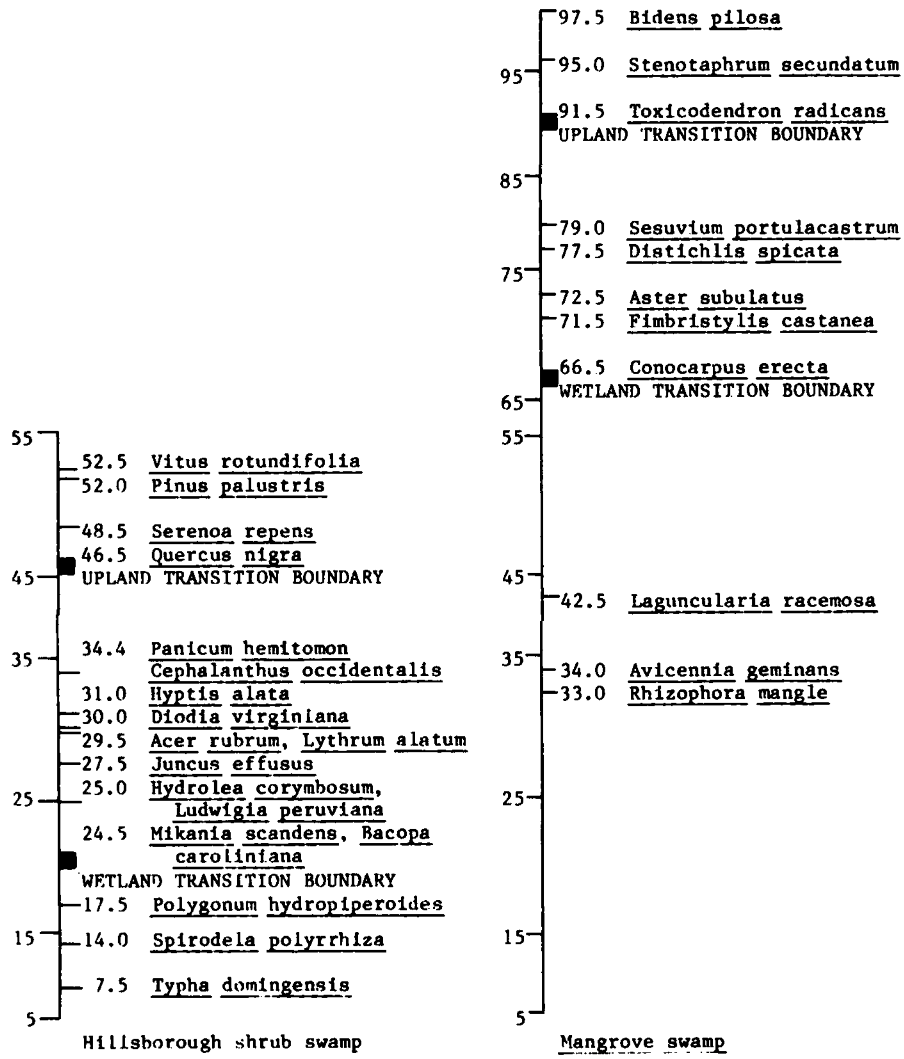


Figure 18. Weighted averages of species along wetland-upland gradient, Hillsborough shrub swamp and mangrove swamp

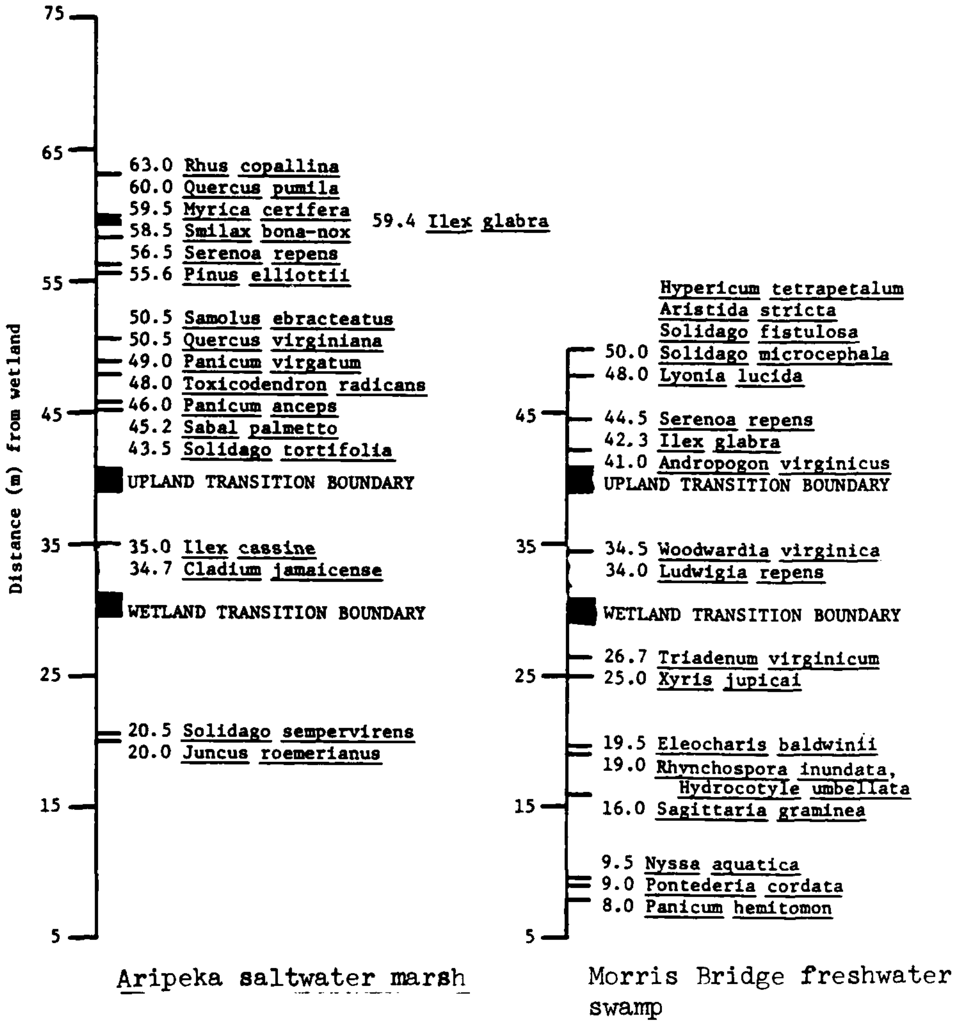


Figure 19. Weighted averages of species along wetland-upland gradient, Aripeka saltwater marsh and Morris Bridge freshwater swamp

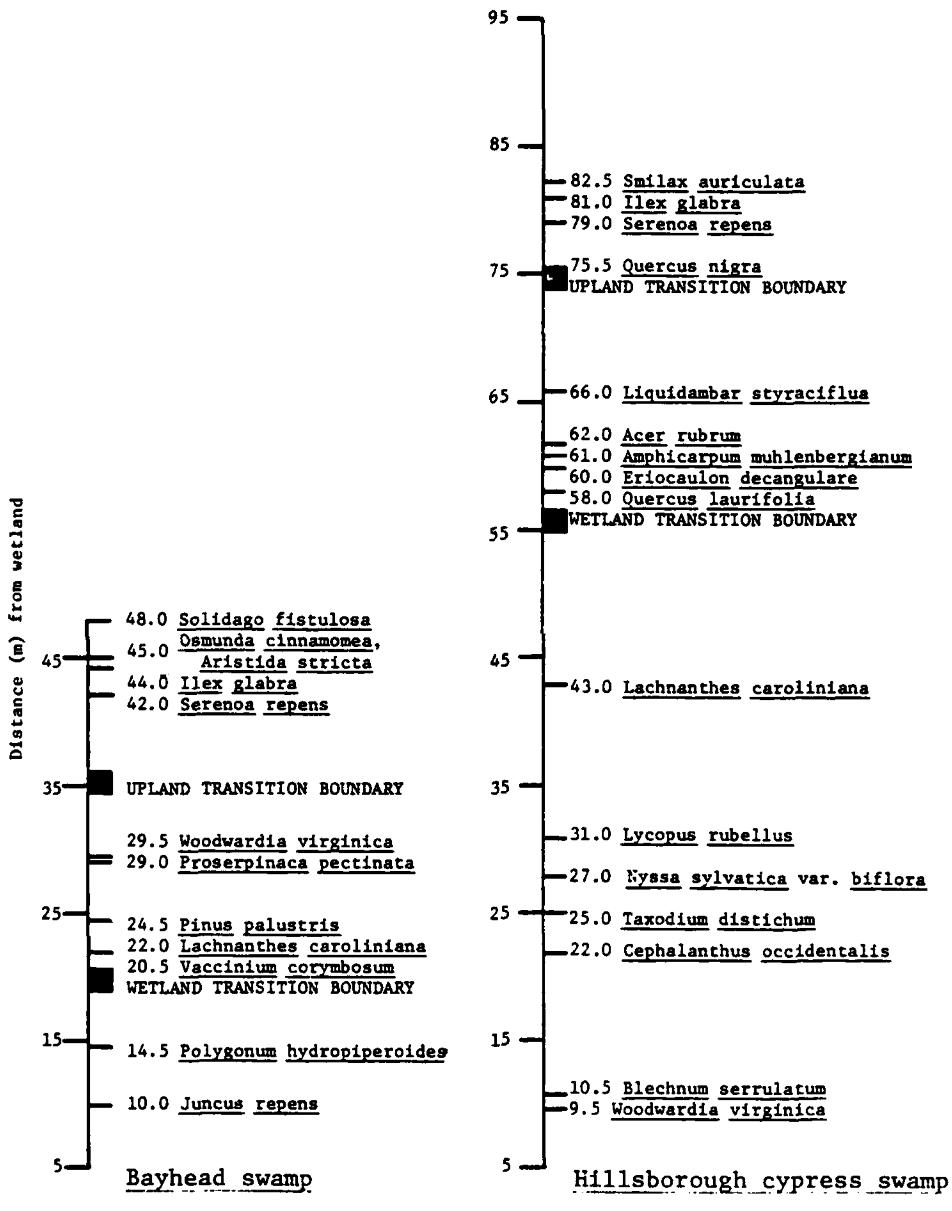


Figure 20. Weighted averages of species along wetland-upland gradient, bayhead swamp and Hillsborough cypress swamp

(*Woodwardia virginica* at 29.5 m and *Proserpinaca pectinata* at 29.0 m) were separated by a minimum distance of 4.5 m from their three closest neighbors toward the wetland. These next three have a mean distance of 2.7 ± 0.73 m and are separated from the two lowest species by 6 m. Three groups are present in the community. However, consistent with the PS method of determining the boundaries starting from the upland, the group closest to the upland is chosen as a boundary and marks the wetland-transition boundary. The next break below this at 20 m is considered to mark a zone within the wetlands. The boundaries determined by this method are marked on Figures 17 through 20.

Method III. Subjective
delineation of boundaries

130. Boundaries determined by the two objective methods (I and II), as well as boundaries determined subjectively by the field investigators (Method III), are shown for comparison in Table 6. The boundaries determined subjectively differed by more than 5 m for three of the eight transition-upland boundaries determined from the PS or WA methods and for two of the eight wetland-transition boundaries. The subjectively determined transition-upland boundaries tend to be lower where they differ than those determined by the PS and WA methods. The wetland-transition boundaries are also lower.

131. The subjective method was more likely to result in narrower wetland and wetland-transition zones, which may be due to using the upper or lower limit of a single dominant species to determine boundaries rather than using the combined changes of all frequent species in a zone. Another reason may be that the lower "tails" of distribution of upland species were more striking to the observer than the "tails" marking the upper limits of wetland species. The same wetland and upland endpoints were subjectively chosen for both belt transect and quantitative sampling. Methods differed in discerning where the most distinct changes occurred along the gradient.

Table 6

Transition Zone Boundaries as Determined by Percent Similarity (PS), Weighted Average (WA), and Subjective (Sbj) Methods

Site	Boundary Distance (Metres from Wetland Endpoint) Wetland-Transition Zone	Transition-Upland Zone
Salt marsh		
PS	30	55
WA	30	40
Sbj	35	55
Morris Bridge freshwater marsh		
PS	35	45
WA	30	40
Sbj	25	45
Hillsborough River marsh		
PS	70	80
WA	30	75
Sbj	35	65
Mangrove swamp		
PS	65	90
WA	65	90
Sbj	65	75
Hillsborough shrub swamp		
PS	20	45
WA	20	45
Sbj	25	35
Bayhead swamp		
PS	20	40
WA	20	35
Sbj	25	45

(Continued)

Table 6 (Concluded)

Site	Boundary Distance (Metres from Wetland Endpoint)	
	Wetland-Transition Zone	Transition-Upland Zone
Hillsborough cypress swamp		
PS	50	80
WA	55	75
Sbj	25	80
Morris Bridge cypress swamp		
PS	45	70
WA	45	65
Sbj	30	60

Phase II: Discussion

Comparison of delineation methods

132. The PS method was the most straightforward, easily calculated, and objective of the three methods. The value of the PS minima could be used to estimate the distinctness of the zones. The WA method was simple to use when the species groups were clearly distinguished; it required much more calculation than the PS method when the species centers were more regularly spaced over the gradient, because intergroup and intragroup distances for many species combinations had to be calculated. Moreover, it did not take dispersion of species into account.

133. In six of the eight communities, the two analytical methods indicate similar boundaries (within 5 m of one another). The upland boundary of the salt marsh is 15 m higher when delineated by the PS method. The uppermost species in the salt marsh upland showed a regular spacing of central points with no break until near the wetland. The difference shown between the methods may be due to the fact that differences in dispersion of species are not so important with the WA method, and the salt marsh has many species that are widely distributed over the gradient. For example, *Sabal palmetto* has a central position at 45 m, but its range extends from 25 m all the way into the upland (Figure 19).

134. The greatest discrepancy between the two methods occurred in the Hillsborough River marsh site: the wetland-transition boundary was at 70 m (10 m below the upland-transition boundary) when the PS method was used, but it was at 30 m by the WA method. This marsh has two PS minima (Figure 17) near the upland that are within 10 m of each other. The next lowest PS minimum is 30 m, which is the same as the boundary of 30 that was indicated by the WA method. However, the species above this segment include such wetland species as buttonbush, maidencane, beak rush, and a disjunct population of floating hearts, indicating that this break is within the wetland rather than between wetland and the transition zone. Contributing to the discrepancy were gaps in the distribution of wetland species caused by the occurrence of low pockets along the transect areas that supported islands of wetland species. We

located the transition-wetland boundary above these wetland pockets, rather than considering them to be part of the transition zone.

135. Where the results of applying the two methods differed, the PS method indicated the most satisfactory boundary. It was also the simplest to calculate in most cases.

136. The identification of species groups by the WA method is interesting from the standpoint of studying species relationships in response to gradients of different wetland types. These relationships are discussed further in the following sections.

137. Boundaries defined by the two analytical methods agree more closely than the subjectively chosen boundaries. The analytical methods would seem, then, more closely linked to inherent properties of the data. When subjective delineation disagreed with the analytically determined boundaries, it led to a smaller portion of the community being defined as a wetland. Results of the comparison between subjective and analytical approaches illustrate the need to develop a workable objective method for boundary determination.

Characterization of the Transition Zones of the Eight Sites

Swamp communities

138. Transition zones of swamp communities extended from wetland edges dominated by woody species to more or less open flatwoods. The nature of the change, whether gradual or distinct, had no relationship to length of the zone. Herbaceous cover, usually of species exclusively found in the transition zone, increased toward the upland, then increased or decreased depending on the nature of the upland, and was influenced by fire frequency and seral stage. The one exception was the Morris Bridge riverine swamp, which remained forested in the transition zone, although there was a change in tree species composition. A different kind of moisture gradient occurred here than in the other isolated freshwater swamps.

139. Bayhead swamp. The vegetation in this site graded from a wetland with closed evergreen canopy and dense shrub layer of wax myrtle

and swamp blueberry to an open, herb-dominated sandhill of scattered pines and turkey oaks. The transition zone was dominated by shrubs, swamp blueberry, and wax myrtle near the wetland and by wax myrtle and saw palmetto near the upland. The transition zone was 20 m long.

140. Hillsborough River shrub swamp. This shrub swamp was in a seral stage from marsh to swamp. The wetland was dominated by shrubs, buttonbush, and primrose willow, but herbaceous ground cover increased in density toward the upland. Maidencane and other herbaceous species shared dominance with primrose willow and red maple. The upland edge of the transition zone showed decreasing dominance of herbs as both shrub and tree cover increased. The transition zone of this swamp was 20 m long.

141. Hillsborough River cypress swamp. The transition zone ranged from the edge of a typical cypress dome with a scattered shrub and a diverse herbaceous layer to a shrub- and tree-dominated upland. It was marked by a distinct herbaceous zone dominated by blue maidencane and pipewort, species that occurred only within the transition zone. The higher portion of the transition zone contained sweetgum, as well as water oak, that extended into the upland. The transition zone was 30 m long.

142. Morris Bridge cypress swamp. The transition zone started at the edge of a riverine swamp dominated by trees and shrubs with little herbaceous cover. The transition to upland was more gradual than in the other flatwood-surrounded swamps. Laurel oak and cabbage palm were major components, and slash pine gradually increased in dominance at the upper end of the zone. The extended zones of laurel oak, cabbage palm, and sawgrass and the extension of slash pine into the transition zone from the upland illustrate the gradual transition. *Panicum anceps* was frequent at the lower end of the transition zone, and bracken fern was frequent at the upper end. The herbaceous layer never became dominant in the transition zone, which was 25 m long.

143. Mangrove swamp. The mangrove swamp had the most distinct transition zone of any of the communities. It was 25 m long and extended from the shrub-dominated wetland zone to a layer of southern pine

flatwoods with dense shrubs and disturbed open clearings of wiregrass, St. Augustine grass, and Spanish needles. A shrub-herb assemblage dominated the transition zone. Species found only in the transition zone were buttonwood, salt grass, aster, and sea purslane. Two major gradients, moisture and salinity, may have reinforced species differentiation in the transition zone.

Marsh communities

144. The freshwater marshes had short transition zones in comparison to the salt marsh and the swamp communities. More marshes in the area would have to be studied to draw firm conclusions, but short transitions may be a recent phenomenon resulting from lowering of the water table in the region.

145. All three marshes showed an increase in shrub cover in and near the transition zone. Shrubs in the salt marsh were species confined to the zone; in Morris Bridge, upland species (saw palmetto, gallberry, and fetterbush) extended into the zone and in Hillsborough River State Park there was a combination of all three types--wetland (buttonbush), transition (shrubby St. John's wort (*Hypericum fasciculatum*)), and upland (gallberry).

146. Salt marsh. The 25-m-long transition zone extended from a black needlerush-dominated marsh to open, dry flatwoods with a diverse shrub and herbaceous layer. Solution cavities in the transition zone created islands of mesic areas. The zone was largely shrub-dominated, with open herbaceous areas. The mesic islands resulted in disjunct occurrences of sawgrass, switchgrass, poison ivy, and red cedar (*Juniperus virginiana*), resulting in alternating shrub and herbaceous areas. Trees increased in dominance as the upland was approached. Several shrubs, including dahoon holly and marsh elder, were confined to the transition zone.

147. Hillsborough River freshwater marsh. The transition zone from herbaceous-dominated marsh to the dense shrub and scattered trees of pine flatwoods was only 10 m long. This situation is artificial due to a ditch surrounding the marsh, which shortened the moisture gradient. Maidencane, buttonbush, and a variety of herbs dominated the diverse

marsh. No species marked the transition zone; wetland species quickly phased out, and many upland species extended into the wetland. A zonal distinction did occur 30 m from the wetland endpoint. Shrubby St. John's wort, redroot, pipewort, blue maidencane, and mermaid weed (*Proserpinaca pectinata*), all of which are transition zone plants in other sites studied, were present, but individuals of these species occurred with buttonbush, maidencane, floating hearts, and horned rush, which are typically wetland plants. The zones may be changing because of a lowered water level resulting from ditching. However, analytical methods still identified the area as a wetland.

148. Morris Bridge freshwater marsh. The transition zone was only 10 m long in this zone. It extended from a maidencane and pickerelweed marsh to open, herbaceous-dominated pine flatwoods. Most wetland species stopped at the wetland-transition boundary, and the transition zone was distinguished by increased shrub cover caused by extensions of gallberry and saw palmetto from the upland. Yellow-eyed grass, spike rush, and Virginia chain fern extended from the upper part of the wetland.

General Transition Zone Characteristics in the Study Area

149. Although it is not recommended that they be used to define zones, several common attributes characterize the transition zones.

Physiognomic diversity

150. Almost all the communities showed a change in physiognomic type within the transition zone. With the exception of the Morris Bridge riverine swamp, transition zones of swamps were dominated by lower strata (either shrubs, herbs, or a combination of two) than were present in the wetlands. Transition zones of the marshes showed increased stratification; shrubs dominated these zones rather than the herbaceous species of the wetlands. Figure 21 illustrates the percent of physiognomic composition of each wetland type by zone. Change in cover is even more striking than change in the number of species representing each physiognomic type.

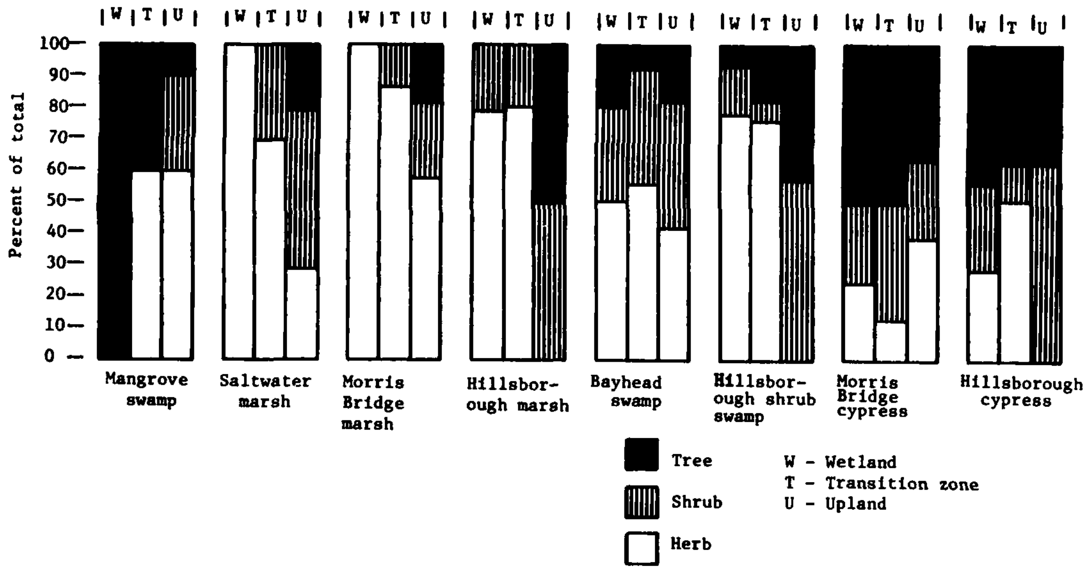


Figure 21. Physiognomic types (tree, shrub, herb) present in each community as percent of total number of species with frequency greater than 20 percent

Relationship to upland and wetland

151. Percent similarities based on species frequency in each of the three zones were computed between the transition zones and the adjacent wetland and upland zones. Separate percent similarities between zones and by strata (tree, shrub, herb) were also computed (Table 7). PS values calculated from the belt frequency data were invariably higher between transition and wetland zones than between the transition and upland zones; such data indicate that transition zones are more closely related to the wetland than to the upland zones. The quantitative data illustrate the importance of particular physiognomic types in determining the PS value. With the exception of the Morris Bridge riverine swamp, shrubs and herbaceous species are the most important species bridging the zones in the sites. This is shown by the fact that higher degrees of similarity (PS) occur for these strata than for the tree strata among groups.

Species composition of ecological groups

152. Method II identified species groups by clustering of WA values in certain locations along the moisture gradient. However, although

Table 7

Comparison of Percent Similarity (PS) Relationships of Transition Zones to Adjacent Wetland and Upland Zones

		PS Relationship Between Zones			
		Quadrat Quantitative Data		Belt Transect Frequency Data*	
Zone	Stratum	Wetland-Transition Zone	Transition-Upland Zone	Wetland-Transition Zone	Transition-Upland Zone
Salt marsh	Tree	0.0	0.0		
	Shrub	0.0	0.0	30.3	23.3
	Herb	32.0	8.0		
Morris Bridge freshwater marsh	Tree	0.0	0.0		
	Shrub	0.0	44.0	76.1	57.5
	Herb	82.7	16.0		
Hillsborough River marsh	Tree	0.0	0.0	42.1	16.3
	Shrub	6.2	0.0		
	Herb	3.4	0.0		
Mangrove swamp	Tree	0.0	0.0		
	Shrub	42.5	0.0	36.5	34.0
	Herb	1.6	1.6		
Hillsborough shrub swamp	Tree	0.0	0.0		
	Shrub	66.0	3.0	48.8	32.5
	Herb	19.2	0.0		
Bayhead swamp	Tree	0.0	0.0		
	Shrub	43.1	38.4	51.6	26.6
	Herb	15.0	8.5		
Hillsborough cypress swamp	Tree	0.0	0.0		
	Shrub	0.0	19.3	41.2	40.2
	Herb	0.0	3.9		
Morris Bridge cypress swamp	Tree	22.8	45.6		
	Shrub	37.8	59.4	48.1	34.4
	Herb	43.0	0.0		

* Combined data for all three strata.

many species were shared by several communities, species associated in a group differed among communities (Table 8). Maidencane and horned rush are associated with pickerelweed in the wetland of the Morris Bridge freshwater marsh, yet they are associated with shrubby St. John's wort in the transition zone of the Hillsborough freshwater marsh. Pickerelweed and buttonbush are grouped in the wetland of this marsh. In the Hillsborough shrub swamp, maidencane and buttonbush occur together in the transition zone. In the Hillsborough cypress swamp, buttonbush and Virginia chain fern occur together in the wetland zone along with pond cypress, although Virginia chain fern occurs in the transition zone in the bayhead swamp and the Morris Bridge freshwater marsh. WA values of upland species tend to be restricted to the upland zone.

153. Many communities shared species in all three zones. Wiregrass, muscadine grape, pawpaw, gallberry, and saw palmetto were present in over half of the upland communities (Table A3). Mermaid weed, redroot, and marsh fleabane were common in the transition zones. Swamp tupelo was present in all the freshwater swamp communities. Maidencane occurred in the freshwater marshes and shrub swamp; buttonbush was present in five of the six freshwater communities. Some species were not confined to a particular zone; red maple, wax myrtle, groundsel, and laurel oak appeared in all zones and were present in at least half of the communities. Apparently, an environmental factor other than the moisture gradient affected their distributions. The first three of these species are successful invaders of disturbed areas.

154. It is not surprising that co-occurring species vary with the community, demonstrating again that species respond independently to both the component variables that form the moisture gradient and fire, which is a major influence on the species composition of Florida wetlands.

155. Disturbance in the upland or wetlands also affects the distribution of transition zone species. For example, trees and shrubs normally occur at the upper limits of black needlerush salt marshes, but it was observed that where trees were cleared from this area, black needlerush extended much farther upland than usual. Apparently, shade

Table 8

Position* by Zone of Selected Species Shared in Common by Several Communities

Zone	Community	Location of Species Group	Species Sharing Location
Wetland	Morris Bridge freshwater marsh	5 to 10 m	maidencane (*Panicum hemitomon*) pickerelweed (*Pontederia cordata*) horned rush (*Rhynchospora inundata*)
Wetland	Hillsborough freshwater marsh	5 to 15 m	buttonbush (*Cephalanthus occidentalis*) pickerelweed (*Pontederia cordata*)
Wetland	Hillsborough cypress swamp	5 m	Virginia chain fern (*Woodwardia virginica*)
		15 to 25 m	buttonbush (*Cephalanthus occidentalis*) pond cypress (*Taxodium ascendens*) swamp tupelo (*Nyssa sylvatica* var. *biflora*)
		40 m	red root (*Lachnanthes caroliniana*)
Transition	Morris Bridge freshwater marsh	30 to 35 m	Virginia chain fern (*Woodwardia virginica*)
Transition	Hillsborough freshwater marsh	35 to 40 m (differs from PS-chosen zone)	maidencane (*Panicum hemitomon*) horned rush (*Rhynchospora inundata*) shrubby St. John's wort (*Hypericum fasciculatum*) blue maidencane (*Amphicarpum muhlenbergianum*) pipewort (*Eriocaulon decangulare*) mermaid weed (*Proserpinaca pectinata*)
Transition	*Hillsborough* shrub swamp	25 to 30 m	red maple (*Acer rubrum*) maidencane (*Panicum hemitomon*) buttonbush (*Cephalanthus occidentalis*)
Transition	Bayhead swamp	30 m	Virginia chain fern (*Woodwardia virginica*)
Transition	Hillsborough cypress swamp	55 to 65 m	red maple (*Acer rubrum*) blue maidencane (*Amphicarpum muhlenbergianum*) pipewort (*Eriocaulon decangulare*)
Upland	Morris Bridge freshwater marsh	50 m and above	saw palmetto (*Serenoa repens*) wiregrass (*Aristida stricta*)
Upland	Hillsborough freshwater marsh	75 m and above	saw palmetto (*Serenoa repens*) muscadine grape (*Vitus rotundifolia*)
Upland	Hillsborough shrub swamp	50 m and above	saw palmetto (*Serenoa repens* muscadine grape (*Vitus rotundifolia*) water oak (*Quercus nigra*)
Upland	Bayhead swamp	40 m and above	saw palmetto (*Serenoa repens*) wiregrass (*Aristida stricta*)
Upland	Hillsborough cypress swamp	75 m and above	saw palmetto (*Serenoa repens*) water oak (*Quercus nigra*)

* Position was determined by weighted averages of the species, and location of the species group is the distance in metres from the wetland endpoint.

intolerance as well as salinity and moisture are factors in determining black needlerush distribution. When the water table is lowered or when a wetland is partially drained, transition zone vegetation may extend farther into the wetland and may co-occur with wetland vegetation. Using particular species as an indicator of wetland and transition zones is particularly inappropriate in Florida, yet Florida State law regulating wetland development (Chapter 17-4, Rules of the Department of Environmental Regulation) includes the following species, if dominant, as indicating the "...landward extent of waters of the state": maidencane, pickerelweed, swamp tupelo, and pond cypress. Species that are considered by the law as transitional, such that the "...landward extent of the waters" is defined only as the "...waterward quarter of the area covered, or 50 feet, whichever is greater," include buttonbush, switch grass, and primrose willow. Results of this study revealed that buttonbush occurs more often in the wetlands than in the transition zone. Switch grass was an upland plant in the salt marsh; and primrose willow, though centered in the transition zone in the Hillsborough shrub swamp, also was dominant in the wetland. Clearly, the use of indicator species for defining wetland boundaries is ambiguous and inconsistent.

Species diversity

156. Species diversity, defined as the number of species occurring in each zone, is shown in Table 9. The fewest wetland species occurred in saline communities (mangrove swamp and salt marsh, with three and nine species, respectively). The freshwater marshes had a moderately high diversity, with 14 species. The greatest species diversity occurred in freshwater swamps, with numbers ranging from 17 to 31 species. If one considers only the more frequently occurring species (20 percent or greater), the ranking of wetlands remains the same, except for the Hillsborough cypress swamp. This community had a large number of infrequently occurring herbaceous species.

157. Species diversity in transition zones generally was higher than diversity in the wetland zones, particularly for the less diverse communities (Table 9). Six of the eight communities had a higher total number of species in the transition zone than in the wetland. Six of

Table 9

Number of Species Sampled in Wetland (W), Transition (T) and Upland (U) Zones of Eight Communities

Community	Total Number of Species			
	W	T	U	Total
Mangrove swamp	3	17	42	54
Salt marsh	9	17	52	61
Morris Bridge marsh	14	22	36	51
Hillsborough marsh	14	27	38	68
Bayhead swamp	17	22	53	69
Hillsborough shrub swamp	18	25	38	65
Morris Bridge cypress swamp	20	11	19	37
Hillsborough cypress swamp	31	28	38	82
	Number of Species with Frequency of 20 Percent or Greater			
	W	T	U	Total
Mangrove	3	10	10	19
Salt marsh	4	10	14	21
Morris Bridge marsh	11	16	17	30
Hillsborough marsh	9	10	10	27
Bayhead swamp	10	13	12	21
Hillsborough shrub swamp	10	16	7	25
Morris Bridge cypress swamp	12	8	8	17
Hillsborough cypress swamp	7	8	8	19

the eight communities had a greater number of the more frequently occurring species in the transition zone than in the wetland. The particularly marked differences in the saline communities are probably due to the decrease in salinity that occurs along the moisture gradient toward the upland. The two cypress swamps showed either no difference or a decrease in species diversity in the transition zones.

158. The increased diversity in the transition zone is due partly to the extensions of both wetland and upland species into the zone; however, it also results from the presence of several species that typically are restricted to transition zones and co-occur with the extended wetland and upland species. Examples of such species are red root, shrubby St. John's wort, and blue maidencane.

159. Diversity of both life form and species in the transition

zone may be related to a constantly alternating competitive balance between species; this alternation is related to temporal changes in the gradient. These changes occur annually in Florida with its pronounced dry and rainy seasons, and between years when series of consecutive wet years may be followed by several years of lower rainfall.

160. Upland communities adjacent to the transition zone were either as diverse or more diverse than the transition zones with regard to both total number of species and number of frequently occurring species (Table 9). However, the moisture gradient is not as influential a factor in species diversity of upland communities as it is in wetlands. Fire frequency is important in Florida uplands in controlling species diversity (Edmisten 1963).

Location of the wetland boundary

161. Two boundary lines have been identified and discussed in this investigation: the wetland-transition boundary and the upland-transition boundary. Between them they define the transition zone. This investigation has shown that transition zones of most communities have higher species diversity and greater physiognomic diversity, align more closely with the wetland, and are composed of species that tend to alternate between the two zones. Regulatory agencies, however, are compelled to decide on one boundary that separates the area over which they have jurisdiction from areas over which they do not.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

Sampling Method Recommendations

162. Data obtained from quantitative sampling in quadrat and wandering quarter methods were not useful in determining zonal boundaries because sampling was conducted within zones with predetermined boundaries. These data could not be correlated with the belt transect data in the areas shown to be boundaries by the analytical methods. The belt transect data were useful for determining boundaries because vegetation was sampled in successive segments along the gradient. Resolution of the boundaries may have been distinct had the transect segment been shorter than 5 m. The 5-m length was chosen, even though the sampling was conducted in 1-m segments of the transect to provide more replicates with which to determine relative frequency and thus obtain more reliable data.

163. A method combining the best features of the belt transects and quantitative quadrat sampling is recommended. First, a homogeneous yet representative stand of the wetland community should be selected for sampling. If the community differs in various sections due to factors unrelated to the moisture gradient (e.g., salinity or seral stage), then separate determinations should be conducted in the affected sections.

164. Replicate belt transects should be established randomly cross the stand area width. These transects should be perpendicular to the wetland edge using the boundary limit of a dominant wetland species as a common reference endpoint. Such a species might be black needlerush in a salt marsh or bald cypress in a river swamp. The transect should extend into the wetland just enough to obtain a reliable sample of vegetation at that particular zone and should extend parallel to the gradient into the upland.

165. The number of replicate belt transects should be determined by using species-area curves to obtain representative species composition and a running mean of importance of the most common species in each zone for representative species quantities. The running mean involves

computing mean importance for a species until the values show little change with each additional plot sampled (Mueller-Dombois and Ellenberg 1974). A consistent SEM of total species quantities used in this investigation does not ensure an accurate representation of the importance of individual species.

166. The uplands and wetlands are areas where the dominant vegetation is such that there can be no dispute about the nature of the area. For example, the dominance of wiregrass might indicate an upland. The widths of the sampled transect segments should be determined by the nature of the vegetation. Contiguous 1-m lengths of the gradient would give the best boundary resolution in communities similar to those studied for this report. The 1- by 1-m quadrats are suitable for herbaceous species. The 1- by 4-m quadrats can be sampled for shrubs and small trees.

167. Trees present a problem with respect to measuring gradient changes because a large area is required for an adequate sample. This problem is particularly noticeable in circular wetlands such as the Hillsborough River communities and the bayhead swamp where the wetland area is much smaller than the upland area. Counting trees within each 1-m-long zone around the wetland may be one solution to this problem.

168. Sampling should not be conducted separately for each vegetative stratum. Species cover in each quadrat should be considered regardless of the height of the individual. Frequency and percent cover, two rapidly obtained parameters, should be compared with other vegetational parameters (e.g., density and IV) to determine if they are as sensitive to measuring boundary changes. Frequency proved useful for boundary analysis by belt transect and, with more replicate transects, may prove as satisfactory as cover or density measurements. Some advantages are:

- a. Frequency is one of only two parameters (percent cover is the other) by which trees may be compared to herb and shrub. Otherwise, synthetic indices such as IV must be devised for comparative purposes.
- b. The treatment of species absence with frequency data presents less of a problem in statistical analysis than the question of how to treat species absence with other quantitative data (Curran and Swithinbank 1981).

c. Dominance data, unless standardized by converting to proportional percent over the gradient for each species, give more weight to large species over small species. Yet, small species, although they use less of the resources, are just as significant as tall, bushy species in showing changing response to the gradient.

d. Compared with other vegetational parameters, frequency is so rapidly measured that many more samples can be obtained in the same time period, thus increasing reliability.

169. Rogers (1980) reported that when frequency data were recorded, maximum precision occurs after 40 plots, whereas examination of 60 to 100 plots was necessary to obtain stable estimates of cover in 0.5- by 1-m plots in a forest understory. In sampling trees, Goff and Cottam (1967) found little practical difference between the results obtained in gradient analysis "using frequency, density, basal area, and various combinations of these measures." On the other hand, Smartt, Meacock, and Lambert (1976) found that more "interpretable ecological results" were obtained from direct measures of the amount of plant material than from frequency measures; percent cover was preferred but both frequency and percent cover were more informative than unbounded measures such as density and biomass.

Boundary Delineation Recommendations

170. Data from sampling should be analyzed statistically to determine which species show significant change over the gradient. Species that are too infrequently occurring or insensitive to the gradient to show this change should not be used for boundary delineation. The data should be subjected to several transformations and the results of each transformation evaluated with regard to the effect on boundary delineation. Potentially useful procedures include standardization by sample unit, standardization by species importance, and log transformations.

171. The relative importance data should be used to compute PS indices and segment-to-segment PS values. Minimum PS values should be used to determine the location of boundaries as described in Part III.

The transition zones so obtained should be evaluated with regard to other ecological attributes that may affect results, such as disturbance history. Detailed descriptions of the site should accompany boundary delineation results.

172. This method and other methods recommended in the literature or by contractors conducting these investigations in other regions should be analyzed using simulated data so that the sensitivity of these methods to species diversity, rates of species change, and other parameters can be assessed. Distributions of indices suggested for boundary delineation under various types of data should be determined by simulations or, if possible, by analysis.

173. Direct and indirect ordinations of additional wetland studies in Florida might yield information that would assist in the evaluation process. Indirect ordination could be used to determine other major factors that influence the positioning of species along the moisture gradient. Extensive efforts to sample the full range of wetland types that occur in Florida could also be used to determine the typical relative positions of species most likely to occur within any physiognomic type on the wetland-upland axis.

174. These methods would not replace site evaluations because the moisture gradients of many similar wetland types probably represent unique combinations of various hydrologic variables to which each species responds individually. For example, transition zones of freshwater marshes may differ in frequency, height of flooding, and amount of surface runoff received. Species composition and distribution in these zones would not be expected to be the same, but the results of an individual determination could be compared with the general patterns of the region. If a wetland is so small, diverse, or disturbed that sampling adequacy cannot be achieved, then the regional information could be used as a reference to provide the most probable species occurrence, given information from a few samples. Since so many wetlands are disturbed, interrupted, or truncated at the uplands, such a regional study could prove valuable to augment results from field sampling.

175. Additional data on the physical parameters of the sites

should be collected and correlated to vegetational response. Parameters relating to elevation, hydroperiod, soil type, soil moisture, and salinity should be examined.

176. The use of quantitative methods for producing an objective, repeatable, standardized means of performing wetland and transition zone delineation is desirable and feasible. Although much additional research is needed in this field, the development of such evaluative methods would lead to more effective and consistent wetland determinations.

REFERENCES

Alexander, T., and Crook, A. 1974. Recent Vegetational Changes in Southern Florida. Environments of South Florida: Present and Past. In: P. Gleason, ed. Miami Geol. Soc., Mem. 2, pp. 61-72.

Austin, D. F. 1978. Exotic Plants and Their Effects in Southeastern Florida. Env. Con., 5:25-34.

Ball, M. C. 1980. Patterns of Secondary Succession in a Mangrove Forest of Southern Florida. Oecologia, 44:226-235.

Beckenbach, J. R. 1973. Principal Soil Areas of Florida--A Supplement to the General Soils Map. University of Florida, in cooperation with USDA, Bulletin 717.

Catana, H. J. 1963. The Wandering Quarter Method of Estimating Population Density. Ecol., 44:349-360.

Cooke, C. W. 1945. Geology of Florida. Fla. Geol. Survey Bull., 29, 339 pp.

Cottam, G., and Curtis, J. T. 1956. The Use of Distance Measures in Phytosociological Sampling. Ecol., 37:451-460.

Curran, P., and Swithinbank, P. 1981. The Application of Gower's Maximal Predictive Classification to Vegetational Data. J. Biogeo., 8:1-5.

Division of State Planning. 1976. The Florida Land Use and Cover Classification System: A Technical Report. Florida Department of Administration, Bureau of Comprehensive Planning.

Duever, M., and Spangler, D. P. 1979. Resource Inventory and Analysis of the Big Cypress National Preserve. Final Report to the United States Department of Interior. Center for Wetlands, University of Florida, Gainesville, and Ecosystem Research Unit, National Audubon Society, Naples, Fla.

Edmisten, J. A. 1963. The Ecology of the Florida Pine Flatwoods. Ph.D. Dissertation, University of Florida, Gainesville.

Environmental Effects Laboratory. 1978. Preliminary Guide to Wetlands of Peninsular Florida, Major Associations and Communities Identified. Technical Report Y-78-2. U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

ESE, Inc. 1978. An Evaluation of Wetlands Transition Zones in Southern Louisiana. Technical report in preparation, prepared for U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

ESE, Inc. 1979. A Review of Wetlands Types and Quantitative Sampling Methodologies. Interim Report, Literature Survey. Gainesville, Fla.

Gauch, H. G., and Whittaker, R. H. 1972. Comparison of Ordination Techniques, Ecol., 53:868-875.

Goff, F. G., and Cottam, G. 1967. Gradient Analysis: The Use of Species and Synthetic Indices. Ecol., 48:793-805.

Greig-Smith, P. 1964. Quantitative Plant Ecology. 2nd ed. Butterworths, London.

Hill, M. O. 1973. Reciprocal Averaging: An Eigenrector Method of Ordination. J. Ecol., 61:237-249.

Hofstetter, R. 1974. The Effects of Fire on the Pineland and Sawgrass Communities of Southern Florida. In: Environments of South Florida: Present and Past. P. J. Gleason, ed. Miami Geol. Soc., Mem. 2, pp. 201-212.

Hume, L., and Day, J. C. 1972. The Determination of an Efficient Sampling Intensity for Studying Beta Diversity in Plant Communities. Can. J. Bot., 52:189-199.

Lindsey, A. A., Barton, J. D., Jr., and Miles, S. R. 1958. Field Efficiencies of Forest Sampling Methods. Ecol., 39:428-444.

Long, R. W. 1974. Origin of the Vascular Flora of Southern Florida. In: Environments of South Florida: Present and Past, P. J. Gleason, ed. Miami Geol. Soc., Mem. 2, pp. 28-36.

Long, R. W., and Lakela, O. 1976. A Flora of Tropical Florida: A Manual of the Seed Plants and Ferns of Southern Peninsular Florida. Banyan Books, Miami, Fla.

Monk, C. D., 1965. Southern Mixed Hardwood Forests of North-Central Florida. Ecolog. Monogr., 35(4):335-354.

Mueller-Dombois, D., and Ellenberg, H. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, Inc., New York.

Pielou, E. C. 1977. Patterns in Zoned Communities. Mathematical Ecology, Chapter 17. John Wiley and Sons, Inc., New York.

Radford, A. E. 1968. Manual of the Vascular Flora of the Carolinas. University of North Carolina Press.

Rice, E. L., and Kelting, R. W. 1955. The Species-Area Curve. Ecol., 36:7-11.

Ricklefs, R. E., and Lau, M. 1980. Bias and Dispersion of Overlap Indices: Results of Some Monte Carlo Simulations, Ecol., 61:1019-1024.

Rogers, R. S. 1980. Plot Distribution in the Understory of a Beech-Maple Forest: A Comparison of Two Contrasting Sampling Designs. Bull. Torr. Bot. Club, 107:530-538.

Smartt, P. F. M., Meacock, S. E., and Lambert, J. M. 1976. Investigations into the Properties of Quantitative Vegetational Data; Further Data Type Comparisons. J. Ecol., 64:41-78.

van der Maarel, E. 1969. On the Use of Ordination Models in Phytosociology. Vegetation, 19:21-46.

Warde, W. and Petronka, J. W. 1981. A Correction Factor Table for Missing Point-Center Quarter Data. Ecol., 62:491-493.

Wharton, C. H., Odum, H. T., Ewel, K., Duever, M., Lugo, A., Boyt, R., Bartholomew, E., DeBellevue, E., Brown, S., Brown, M., and Duever, L. 1976. Forested Wetlands of Florida--Their Management and Use. Center for Wetlands, University of Florida, Gainesville, 417 pp.

Whittaker, R. H. 1960. Vegetation of the Siskiyou Mountains, Oregon and California. Ecol. Monogr., 30:279-338.

Whittaker, R. H. 1978. Handbook of Vegetation Science, Part V, In: Ordination of Communities, Dr. W. Junk, ed. The Hague Press, The Netherlands.

Whittaker, R. H. 1979. Vegetational Relationships of the Pine Barrens. In: Pine Barrens: Ecosystem and Landscape, R. T. T. Forman, ed. Academic Press, New York.

Wikum, D. A., and Shanholtzer, G. F. 1978. Application of the Braun-Blanquet Cover-Abundance Scale for Vegetation Analysis in Land Development Studies. Envir. Mgt., 2(4):323-329.

APPENDIX A: SPECIES LISTS

Table A1

Common and Scientific Names of Species Sampled in Florida Wetland Communities

Common Name	Scientific Name
Apricot vine	*Passiflora incarnata* L.
Arrowhead	*Sagittaria graminea* Michx.
Aster	*Aster subulatus* Michaux
Bald cypress	*Taxodium distichum* (L.) Richard
Bamboo	*Smilax laurifolia* L.
Beak rush	*Rhynchospora miliacea* (Lam.) Gray
Beak rush	*Rhynchospora tracyi* Britt.
Beard grass	*Andropogon cabanisii* Hack.
Beauty berry	*Callicarpa americana* L.
Black haw	*Viburnum obovatum* Walt.
Black mangrove	*Avicennia germinans* L.
Black needlerush	*Juncus roemerianus* Scheele
Black root	*Pterocaulon virgatum* (L.) B.C.
Black rush	*Juncus repens* Michx.
Blackberry	*Rubus cuneifolius* Pursh
Bladderwort	*Utricularia purpurea* Walt.
Bladderwort	*Utricularia subulata* L.
Blue curls	*Trichostema suffrutescens* Kearney
Blue-jack oak	*Quercus incana* Bartr.
Blue maidencane	*Amphicarpum muhlenbergianum* (Schultes) Hitchc.
Bracken fern	*Pteridium aquilinum* (L.) Kuhn
Brazilian pepper	*Schinus terebinthifolius* Raddi
Broom-sedge	*Andropogon capillipes* Nash
Broom-sedge	*Andropogon virginicus* L.
Bugleweed	*Lycopus rubellus* Moench
Bur-marigold	*Bidens pilosa* L.
Button weed	*Diodia virginiana* L.
Buttonbush	*Cephalanthus occidentalis* L.
Buttonwood	*Conocarpus erecta* L.
Cabbage palm	*Sabal palmetto* (Walt.) Todd. ex Schultes
Camphor tree	*Cinnamomum camphora* (L.) Nees & Eberm.
Capeweed	*Phyla nodiflora* (L.) Greene
Carpet grass	*Axonopus affinis* Chase
Carpet grass	*Axonopus furcatus* (Fluegge) Hitch.
Cattail	*Typha domingensis* Pers.
Christmas berry	*Lycium carolinianum* Walt.
Cinnamon fern	*Osmunda cinnamomea* L.
Climbing hempweed	*Mikania scandens* (L.) Willd.
Coinwort	*Centella asiatica* (L.) Urban
Colic root	*Aletris lutea* Small
Common ragweed	*Ambrosia artemisiifolia* L.
Common willow	*Salix caroliniana* Michx.

(Continued)

(Sheet 1 of 6)

Table A1 (Continued)

Common Name	Scientific Name
Cowpea	*Vigna luteola* (Jacquin) Bentham
Croton	*Croton glandulosus* L.
Dahoon holly	*Ilex cassine* L.
Dangleberry	*Gaylussacia frondosa* (L.) T&G
Deer's tongue	*Carphephorus corymbosus* (Nutt.) T&G
Dichanthelium grass	*Dichanthelium aciculare* (Desvaux ex. Poiret) Gould & Clark
Dog fennel	*Eupatorim capillifolium* (Lam.) Small
Dwarf horseweed	*Conyza canadensis* (L.) Cronquist
Dwarf huckleberry	*Gaylussacia domosa* (Andrews) T&G
Dwarf live oak	*Quercus geminata* Small
Dwarf St. John's wort	*Hypericum multilum* L.
Elderberry	*Sambucus canadensis* L.
Elephant's foot	*Elephantopus elatus* Bertoloni
False loosestrife	*Ludwigia linearis* Walt.
False loosestrife	*Ludwigia maritima* F. Harper
False loosestrife	*Ludwigia repens* Forst.
False nettle	*Boehmeria cylindrica* (L.) Swartz
False pimpernel	*Lindernia grandiflora* Nutt.
Fen rose	*Kosteletzkya virginica* (L.) Presl.
Fetterbush	*Lyonia lucida* (Lam.) K. Koch
Fimbristylis	*Fimbristylis caroliniana* (Lam.) Fern.
Finger grass	*Eustachys glauca* Chapm.
Fireweed	*Erechtites hieracifolia* (L.) Raf.
Fleabane	*Erigeron vernus* (L.) T&G
Floating hearts	*Nymphoides aquatica* (J.F. Gmel.) Kuntze
Florida elm	*Ulmus americana* var. floridana (Chapm.) Little
Florida privet	*Forestiera segregata* (Jacq.) Krug & Urban
Foxtail grass	*Setaria geniculata* (Lam.) Beauvois
Galingale	*Cyperus brevifolius* (Rottb.) Hassk.
Galingale	*Cyperus haspan* L.
Galingale	*Cyperus tetragonus* Ell.
Gallberry	*Ilex glabra* (L.) Gray
Giant duckweed	*Spirodela polyrrhiza* (L.) Schleid.
Golden Aster	*Heterotheca subaxilaris* (Lam.) Britton & Rusby
Goldenrod	*Solidago fistulosa* Miller
Goldenrod	*Solidago microcephala* (Greene) Bush
Goldenrod	*Solidago sempervirens* L.
Goldenrod	*Solidago tortifolia* Ell.
Greenbrier	*Smilax auriculata* Walt.
Greenbrier	*Smilax bona-nox* L.
Greenbrier	*Smilax walteri* Pursh
Ground cherry	*Physalis angulata* L.
Groundsel	*Baccharis glomeruliflora* Pers.
Hat pins	*Eriocaulon compressum* Lam.

(Continued)

(Sheet 2 of 6)

Table A1 (Continued)

Common Name	Scientific Name
Hat pins	*Eriocaulon decangulare* L.
Hercules club	*Zanthoxylum clava-herculis* L.
Highbush blueberry	*Vaccinium corymbosum* L.
Hornbeam	*Carpinus caroliniana* Walt.
Horned rush	*Rhyncospora inundata* (Oakes) Fern.
Horse mint	*Monarda punctata* L.
Indian grass	*Sorghastrum secundum* (Ell.) Nash
Innocence	*Hedyotis procumbens* (J.F. Gmel.)
Iris	*Iris hexagona* Walt.
Knotweed	*Polygonum hydropiperoides* Michx.
Laurel oak	*Quercus laurifolia* Michx.
Leadplant	*Amorpha herbacea* Walt.
Leaf flower	*Phyllanthus abnormis* Baillon
Leafless cynanchum	*Cynanchum scoparium* Nutt.
Leather fern	*Acrostichum danaeaefolium* Langsd. & Fisch.
Leucothoe	*Leucothoe populifolia* (Lam.) Dippel
Live oak	*Quercus virginiana* Mill.
Lizzard's tail	*Saururus cernuus* L.
Loblolly bay	*Gordonia lasianthus* (L.) Ellis
Loosestrife	*Lythrum alatum* Pursh
Loosestrife	*Lythrum lineare* L.
Love vine	*Cassytha filiformis* L.
Maidencane	*Panicum hemitomon* Schult.
Maleberry	*Lyonia ligustrina* (L.) DC.
Marsh elder	*Iva frutescens* L.
Marsh-elder	*Iva microcephala* Nutt.
Marsh fleabane	*Pluchea rosea* R.K. Godfrey
Marsh hay cordgrass	*Spartina patens* (Ait.) Muhl.
Marsh pink	*Sabatia difformis* (L.) Druce
Melanthera	*Melanthera nivea* (L.) Small
Mermaid weed	*Proserpinaca pectinata* Lam.
Micranthemum	*Micranthemum glomeratum* (Chapm.) Shinners
Milk pea	*Galactia elliottii* Nutt.
Milk pea	*Galactia volubilis* (L.) Britt.
Milkwort	*Polygala cymosa* Walt.
Muscadine	*Vitis rotundifolia* Michx.
Musky mint	*Hyptis alata* (Raf.) Shinners
Natal grass	*Rhynchelytrum repens* (Willd.) C.E. Hubbard
Necklace pod	*Sophora tomentosa* L.
Netted chain fern	*Woodwardia areolata* (L.) Moore
Nut rush	*Scleria ciliata* Michx.
Nut rush	*Scleria triglomerata* Michx.
Old man's beard	*Chionanthus virginica* L.
Painted leaf	*Poinsettia heterophylla* (L.) Kl. & Gke.
Panic grass	*Panicum anceps* Michx.

(Continued)

(Sheet 3 of 6)

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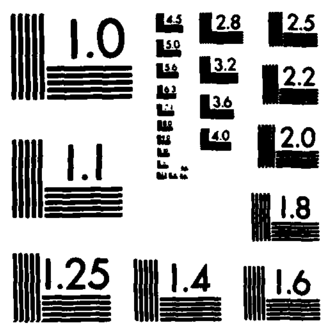

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Table A1 (Continued)

Common Name	Scientific Name
Panic grass	*Panicum breve* Hitchc. & Chase
Panic grass	*Panicum gymnocarpon* Ell.
Panic grass	*Panicum hians* Ell.
Panic grass	*Panicum verrucosum* Muhl.
Panic grass	*Panicum xalapense* HBK
Pawpaw	*Asimina reticulata* Shuttlew. ex Chapm.
Pepper-vine	*Ampelopsis arborea* (L.) Koehne
Persimmon	*Diospyros virginiana* L.
Pickerelweed	*Pontederia cordata* L.
Pink sundew	*Drosera capillaris* Poir.
Poison ivy	*Toxicodendron radicans* (L.) Kuntze
Polypremum	*Polypremum procumbens* L.
Pond cypress	*Taxodium ascendens* Brogn.
Prairie clover	*Petalostemum carneum* Michx.
Prickly pear	*Opuntia stricta* Haw.
Primrose willow	*Ludwigia peruviana* (L.) Hara
Purple thistle	*Cirsium horridulum* Michx.
Queen's delight	*Stillingia sylvatica* Garden
Red chokeberry	*Pyrus arbutifolia* (L.) L. F.
Red mangrove	*Rhizophora mangle* L.
Red maple	*Acer rubrum* L.
Red root	*Lachnanthes caroliniana* (Lam.) Dandy
Rhynchosia	*Rhynchosia reniformis* DC.
Running oak	*Quercus pumila* Walt.
Rush	*Juncus biflorus* Michx.
Rush	*Juncus scirpoides* Lam.
Rusty lyonia	*Lyonia fruticosa* (Michx.) G. S. Torr.
Saffron plum	*Bumelia celastrina* HBK
Salt grass	*Distichlis spicata* (L.) Green
Saltmarsh fimbristylis	*Fimbristylis castanea* (Michx.) Vahl.
Sandbur	*Cenchrus longispinus* (Hack.) Fern.
Savory pennyroyal	*Philoblephis rigida* (Bartr.) Raf.
Saw palmetto	*Serenoa repens* (Bartr.) Small
Sawgrass	*Cladium jamaicense* Crantz
Sea daisy	*Borrichia frutescens* (L.) DC
Sea grape	*Coccoloba uvifera* (L.) L.
Sea lavender	*Limonium carolinianum* (Walt.) Britt.
Sea purslane	*Sesuvium portulacastrum* L.
Sedge	*Carex glaucescens* Ell.
Semaphore eupatorium	*Eupatorium mikanioides* Chapm.
Shiny blueberry	*Vaccinium Darrowii* Camp.
Shiny blueberry	*Vaccinium myrsinites* Lam
Sky-flower	*Hydrolea corymbosum* Macbride ex Ell.
Slash pine	*Pinus elliottii* var. *elliottii* Engelm
Snowberry	*Chiococca alba* (L.) Hitchc.

(Continued)

(Sheet 4 of 6)

Table A1 (Continued)

Common Name	Scientific Name
Soft rush	*Juncus effusus* L.
Southern longleaf pine	*Pinus palustris* Mill.
Southern magnolia	*Magnolia grandiflora* L.
Southern red cedar	*Juniperus silicicola* (Small) Bailey
Southern slash pine	*Pinus elliottii* var. *densa* Little & Dorman
Spanish bayonet	*Yucca aloifolia* L.
Spike rush	*Eleocharis baldwinii* (Torr.) Chapm.
Spike rush	*Eleocharis cellulosa* Torr.
Spurge	*Chamaesyce maculata* (L.) Small
St. Andrew's cross	*Hypericum hypericoides* (L.) Crantz
St. Augustine grass	*Stenotaphrum secundatum* (Walt.) Kuntze
St. John's wort	*Hypericum cistifolium* Lam.
St. John's wort	*Hypericum fasciculatum* Lam.
St. John's wort	*Hypericum tetrapetalum* Lam.
St. John's wort	*Triadenum virginicum* (L.) Raf.
Sunflower	*Helianthus radula* (Pursh.) T&G
Sunflower	*Helianthus simulans* E.E. Wats.
Supple-jack	*Berchemia scandens* (Hill) K. Koch.
Swamp blackberry	*Rubus betulifolius* Small
Swamp fern	*Blechnum serrulatum* Richard
Swamp red bay	*Persea palustris* (Raf.) Sarg.
Swamp tupelo	*Nyssa sylvatica* var. *biflora* Walt.
Sweet bay	*Magnolia virginiana* L.
Sweetgum	*Liquidambar styraciflua* L.
Switch grass	*Panicum virgatum* L.
Thoroughwort	*Eupatorium aromaticum* L.
Three-awn grass	*Aristida spiciformis* Ell.
Three-seeded mercury	*Acalypha gracilens* Gray
Tick trefoil	*Desmodium paniculatum* (L.) DC.
Tickseed	*Coreopsis leavenworthii* T&G
Tooth cup	*Rotala ramosior* (L.) Koehne
Turkey oak	*Quercus laevis* Walt.
Umbrella grass	*Fuirena breviseta* Cov.
Violet	*Viola affinia* Le Conte
Virginia chain fern	*Woodwardia virginica* (L.) Small
Virginia creeper	*Parthenocissus quinquefolia* (L.) Planchon
Water ash	*Fraxinus caroliniana* Mill.
Water hemlock	*Cicuta mexicana* C&R
Water hyssop	*Bacopa caroliniana* (Walt.) Robins.
Water locust	*Gleditsia aquatica* Marsh.
Water oak	*Quercus nigra* L.
Water pennywort	*Hydrocotyle umbellata*
Water pimpernel	*Samolus ebracteatus* HBK
Water willow	*Justicia ovata* (Walt.) Lindau
Wax myrtle	*Myrica cerifera* L.

(Continued)

(Sheet 5 of 6)

Table A1 (Concluded)

Common Name	Scientific Name
White mangrove	*Laguncularia racemosa* Gaertn. F.
White-top aster	*Aster reticulatus* Pursh
White-top sedge	*Dichromena colorata* (L.) Hitchc.
White water lily	*Nymphaea odorata* Ait.
Winged sumac	*Rhus copallina* L.
Wiregrass	*Aristida stricta* Michaux
Wood fern	*Thelypteris interrupta* (Willd.) Iwatsuki
Wood fern	*Thelypteris normalis* (C. Chn) Moxley
Yaupon	*Ilex vomitoria* Ait.
Yellow-eyed grass	*Xyris ambigua* Beyrich
Yellow-eyed grass	*Xyris brevifolia* Michx.
Yellow-eyed grass	*Xyris caroliniana* Walt.
Yellow-eyed grass	*Xyris jupicai* Richard
Yellow flax	*Linum medium* var. *texanum* (Planchon) Fern.
Yellow jessamine	*Gelsemium sempervirens* (L.) Aiton/F.
Yellowtop	*Flaveria linearis* Lag.

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Table A2

Common and Scientific Names of Species Sampled in Florida Wetland Communities

Scientific Name	Common Name
Acalypha gracilens Gray	Three-seeded mercury
Acer rubrum L.	Red maple
Acrostichum danaeaefolium Langsd. & Fisch.	Leather fern
Aletris lutea Small	Colic root
Ambrosia artemisiifolia L.	Common ragweed
Amorpha herbacea Walt.	Lead plant
Ampelopsis arborea (L.) Koehne	Pepper-vine
Amphicarpum muhlenbergianum (Schultes) Hitchc.	Blue maidencane
Andropogon cabanisii Hack.	Beard grass
Andropogon capillipes Nash	Broom-sedge
Andropogon virginicus L.	Broom-sedge
Aristida spiciformis Ell.	Three-awn grass
Aristida stricta Michaux	Wiregrass
Asimina reticulata Shuttlew. ex Chapm.	Pawpaw
Aster reticulatus Pursh	White-top aster
Aster subulatus Michaux	Aster
Avicennia germinans L.	Black mangrove
Axonopus affinis Chase	Carpet grass
Axonopus furcatus (Fluegge) Hitch.	Carpet grass
Baccharis angustifolia Michx.	False willow
Baccharis glomeruliflora Pers.	Groundsel
Baccharis halimifolia L.	Groundsel
Bacopa caroliniana (Walt.) Robins.	Water hyssop
Berchemia scandens (Hill) K. Koch.	Supple-jack
Bidens pilosa L.	Bur-marigold
Blechnum serrulatum Richard	Swamp fern
Boehmeria cylindrica (L.) Swartz	False nettle
Borrichia frutescens (L.) DC	Sea daisy
Bumelia celastrina HBK	Saffron plum
Callicarpa americana L.	Beauty berry
Carex glaucescens Ell.	Sedge
Carphephorus corymbosus (Nutt.) T&G	Deer's tongue
Carpinus caroliniana Walt.	Hornbeam
Cassytha filiformis L.	Love vine
Cenchrus longispinus (Hack.) Fern.	Sandbur
Centella asiatica (L.) Urban	Coinwort
Cephalanthus occidentalis L.	Buttonbush
Chamaesyce maculata (L.) Small	Spurge
Chiococca alba (L.) Hitchc.	Snowberry
Chionanthus virginica L.	Old man's beard
Cicuta mexicana C&R	Water hemlock

(Continued)

(Sheet 1 of 6)

Table A2 (Continued)

Scientific Name	Common Name
Cinnamomum camphora (L.) Nees & Eberm.	Camphor tree
Cirsium horridulum Michx.	Purple thistle
Cladium jamaicense Crantz	Sawgrass
Coccoloba uvifera (L.) L.	Sea grape
Conocarpus erecta L.	Buttonwood
Conyza canadensis (L.) Cronquist	Dwarf horseweed
Coreopsis leavenworthii T&G	Tickseed
Croton glandulosus L.	Croton
Cynanchum scoparium Nutt.	Leafless cynanchum
Cyperus brevifolius (Rottb.) Hassk.	Galingale
Cyperus haspan L.	Galingale
Cyperus tetragonus Ell.	Galingale
Desmodium paniculatum (L.) DC.	Tick trefoil
Dichanthelium aciculare (Desvaux ex. Poiret) Gould & Clark	Dichanthelium grass
Dichromena colorata (L.) Hitchc.	White-top sedge
Diodia virginiana L.	Button weed
Diospyros virginiana L.	Persimmon
Distichlis spicata (L.) Green	Salt grass
Drosera capillaris Poir.	Pink sundew
Eleocharis baldwinii (Torr.) Chapm.	Spike rush
Eleocharis cellulosa Torr.	Spike rush
Elephantopus elatus Bertoloni	Elephant's foot
Erechtites hieracifolia (L.) Raf.	Fireweed
Erigeron vernus (L.) T&G	Fleabane
Eriocaulon compressum Lam.	Hat pins
Eriocaulon decangulare L.	Hat pins
Eupatorium aromaticum L.	Thoroughwort
Eupatorium capillifolium (Lam.) Small	Dog fennel
Eupatorium mikanioides Chapm.	Semaphore eupatorium
Eustachys glauca Chapm.	Finger grass
Fimbristylis caroliniana (Lam.) Fern.	Fimbristylis
Fimbristylis castanea (Michx.) Vahl.	Saltmarsh fimbristylis
Flaveria linearis Lag.	Yellowtop
Forestiera segregata (Jacq.) Krug & Urban	Florida privet
Fraxinus caroliniana Mill.	Water ash
Fuirena breviseta Cov.	Umbrella grass
Galactia elliottii Nutt.	Milk pea
Galactia volubilis (L.) Britt.	Milk pea
Gaylussacia dumosa (Andrews) T&G	Dwarf huckleberry
Gaylussacia frondosa (L.) T&G	Dangleberry
Gelsemium sempervirens (L.) Aiton/F.	Yellow jessamine
Gleditsia aquatica Marsh.	Water locust
Gordonia lasianthus (L.) Ellis	Loblolly bay
Hedyotis procumbens (J.F. Gmel.)	Innocence

(Continued)

(Sheet 2 of 6)

Table A2 (Continued)

Scientific Name	Common Name
Helianthus radula (Pursh.) T&G	Sunflower
Helianthus simulans E.E. Wats.	Sunflower
Heterotheca subaxilaris (Lam.) Britton & Rusby	Golden aster
Hydrocotyle umbellata L.	Water pennywort
Hydrolea corymbosum Macbride ex Ell.	Sky-flower
Hypericum cistifolium Lam.	St. John's wort
Hypericum fasciculatum Lam.	St. John's wort
Hypericum hypericoides (L.) Crantz	St. Andrew's cross
Hypericum multilum L.	Dwarf St. John's wort
Hypericum tetrapetalum Lam.	St. John's wort
Hyptis alata (Raf.) Shinners	Musky mint
Ilex cassine L.	Dahoon holly
Ilex glabra (L.) Gray	Gallberry
Ilex vomitoria Ait.	Yaupon
Iris hexagona Walt.	Iris
Iva frutescens L.	Marsh elder
Iva microcephala Nutt.	Marsh elder
Juncus biflorus Michx.	Rush
Juncus effusus L.	Soft rush
Juncus repens Michx.	Black rush
Juncus roemerianus Scheele	Black needlerush
Juncus scirpoides Lam.	Rush
Juniperus silicicola (Small) Bailey	Southern red cedar
Justicia ovata (Walt.) Lindau	Water willow
Kosteletzkya virginica (L.) Presl.	Fen rose
Lachnanthes caroliniana (Lam.) Dandy	Red root
Laguncularia racemosa Gaertn. F.	White mangrove
Leucothoe populifolia (Lam.) Dippel	Leucothoe
Limonium carolinianum (Walt.) Britt.	Sea lavender
Lindernia grandiflora Nutt.	False pimpernel
Linum medium var. *texanum* (Planchon) Fern.	Yellow flax
Liquidambar styraciflua L.	Sweetgum
Ludwigia linearis Walt.	False loosestrife
Ludwigia maritima F. Harper	False loosestrife
Ludwigia peruviana (L.) Hara	Primrose willow
Ludwigia repens Forst.	False loosestrife
Lycium carolinianum Walt.	Christmas berry
Lycopus rubellus Moench	Bugleweed
Lyonia fruticosa (Michx.) G. S. Torr.	Rusty lyonia
Lyonia ligustrina (L.) DC.	Maleberry
Lyonia lucida (Lam.) K. Koch	Fetterbush
Lythrum alatum Pursh	Loosestrife
Lythrum lineare L.	Loosestrife
Magnolia grandiflora L.	Southern magnolia
Magnolia virginiana L.	Sweet bay

(Continued)

(Sheet 3 of 6)

Table A2 (Continued)

Scientific Name	Common Name
Melanthera nivea (L.) Small	Melanthera
Micranthemum glomeratum (Chapm.) Shinners	Micranthemum
Mikania scandens (L.) Willd.	Climbing hempweed
Monarda punctata L.	Horse mint
Myrica cerifera L.	Wax myrtle
Nymphaea odorata Ait.	White water lily
Nymphoides aquatica (J.F. Gmel.) Kuntze	Floating hearts
Nyssa sylvatica var. *biflora* Walt.	Swamp tupelo
Opuntia stricta Haw.	Prickly pear
Osmunda cinnamomea L.	Cinnamon fern
Panicum anceps Michx.	Panic grass
Panicum breve Hitch. & Chase	Panic grass
Panicum gymnocarpon Ell.	Panic grass
Panicum hemitomon Schult.	Maidencane
Panicum hians Ell.	Panic grass
Panicum verrucosum Muhl.	Panic grass
Panicum virgatum L.	Switch grass
Panicum xalapense HBK	Panic grass
Parthenocissus quinquefolia (L.) Planchon	Virginia creeper
Passiflora incarnata L.	Apricot vine
Persea palustris (Raf.) Sarg.	Swamp red bay
Petalostemum carneum Michx.	Prairie clover
Philoblephis rigida (Bartr.) Raf.	Savory pennyroyal
Phyla nodiflora (L.) Greene	Capeweed
Phyllanthus abnormis Baillon	Leaf flower
Physalis angulata L.	Ground cherry
Pinus elliottii var. *elliottii* Engelm	Slash pine
Pinus elliottii var. *densa* Little & Dorman	Southern slash pine
Pinus palustris Mill.	Southern longleaf pine
Pluchea rosea R.K. Godfrey	Marsh fleabane
Poinsettia heterophylla (L.) Kl. & Gke.	Painted leaf
Polygala cymosa Walt.	Milkwort
Polygonum hydropiperoides Michx.	Knotweed
Polypremum procumbens L.	Polypremum
Pontederia cordata L.	Pickerelweed
Proserpinaca pectinata Lam.	Mermaid weed
Pteridium aquilinum (L.) Kuhn	Bracken fern
Pterocaulon virgatum (L.) B.C.	Black root
Pyrus arbutifolia (L.) L. F.	Red chokeberry
Quercus geminata Small	Dwarf live oak
Quercus incana Bartr.	Blue-jack oak
Quercus laevis Walt.	Turkey oak
Quercus laurifolia Michx.	Laurel oak
Quercus nigra L.	Water oak
Quercus pumila Walt.	Running oak

(Continued)

Table A2 (Continued)

Scientific Name	Common Name
Quercus virginiana Mill.	Live oak
Rhizophora mangle L.	Red mangrove
Rhus copallina L.	Winged sumac
Rhynchelytrum repens (Willd.) C.E. Hubbard	Natal grass
Rhynchosia reniformis DC.	Rhynchosia
Rhynchospora inundata (Oakes) Fern.	Horned rush
Rhynchospora miliacea (Lam.) Gray	Beak rush
Rhynchospora tracyi Britt.	Beak rush
Rotala ramosior (L.) Koehne	Tooth cup
Rubus betulifolius Small	Swamp blackberry
Rubus cuneifolius Pursh	Blackberry
Sabal palmetto (Walt.) Todd. ex Schultes	Cabbage palm
Sabatia difformis (L.) Druce	Marsh pink
Sagittaria graminea Michx.	Arrowhead
Salix caroliniana Michx.	Common willow
Sambucus canadensis L.	Elderberry
Samolus ebracteatus HBK	Water pimpernel
Saururus cernuus L.	Lizard's tail
Schinus terebinthifolius Raddi	Brazilian pepper
Scleria ciliata Michx.	Nut rush
Scleria triglomerata Michx.	Nut rush
Serenoa repens (Bartr.) Small	Saw palmetto
Sesuvium portulacastrum L.	Sea purslane
Setaria geniculata (Lam.) Beauvois	Foxtail grass
Smilax auriculata Walt.	Greenbrier
Smilax bona-nox L.	Greenbrier
Smilax laurifolia L.	Bamboo
Smilax walteri Pursh	Greenbrier
Solidago fistulosa Miller	Goldenrod
Solidago microcephala (Greene) Bush	Goldenrod
Solidago sempervirens L.	Goldenrod
Solidago tortifolia Ell.	Goldenrod
Sophora tomentosa L.	Necklace pod
Sorghastrum secundum (Ell.) Nash	Indian grass
Spartina patens (Ait.) Muhl.	Marsh hay cordgrass
Spirodela polyrrhiza (L.) Schleid.	Giant duckweed
Stenotaphrum secundatum (Walt.) Kuntze	St. Augustine grass
Stillingia sylvatica Garden	Queen's delight
Taxodium ascendens Brogn.	Pond cypress
Taxodium distichum (L) Richard	Bald cypress
Thelypteris interrupta (Willd.) Iwatsuki	Wood fern
Thelypteris normalis (C. Chn) Moxley	Wood fern
Toxicodendron radicans (L.) Kuntze	Poison ivy
Triadenum virginicum (L.) Raf.	St. John's wort
Trichostema suffrutescens Kearney	Blue curls

(Continued)

(Sheet 5 of 6)

Table A2 (Concluded)

Scientific Name	Common Name
Typha domingensis Pers.	Cattail
Ulmus americana var. *floridana* (Chapm.) Little	Florida elm
Utricularia purpurea Walt.	Bladderwort
Utricularia subulata L.	Bladderwort
Vaccinium corymbosum L.	Highbush blueberry
Vaccinium Darrowii Camp.	Shiny blueberry
Vaccinium myrsinites Lam	Shiny blueberry
Viburnum obovatum Walt.	Black haw
Vigna luteola (Jacquin) Bentham	Cowpea
Viola affinis Le Conte	Violet
Vitis rotundifolia Michx.	Muscadine
Woodwardia areolata (L.) Moore	Netted chain fern
Woodwardia virginica (L.) Small	Virginia chain fern
Xyris ambigua Beyrich	Yellow-eyed grass
Xyris brevifolia Michx.	Yellow-eyed grass
Xyris caroliniana Walt.	Yellow-eyed grass
Xyris jupicai Richard	Yellow-eyed grass
Yucca aloifolia L.	Spanish bayonet
Zanthoxylum clava-herculis L.	Hercules club

(Sheet 6 of 6)

Table A3

Occurrence of Species Sampled by Community and Zone

Species	Community and Zone*							
	MBR	MBM	BS	MS	SM	HC	HM	HSS
Acalypha gracilens			U					
Acer rubrum	W**	U			U	W,T,U	T,U	W,T,U
Acrostichum danaeaefolium					W,T			
Aletris lutea						T		
Ambrosia artemisiifolia			U					
Amorpha herbacea			U					
Ampelopsis arborea	T					W		
Amphicarpum muhlenbergianum						W,T	T	
Andropogon cabanisii		U						
Andropogon capillipes							T	
Andropogon virginicus		U	U		U	T		
Aristida spiciformis		U						
Aristida stricta		U	U	U	U	U	U	U
Asimina reticulata						U	U	U
Aster reticulatus		U	T,U					
Aster subulatus				T				
Avicennia germinans				W,T				
Axonopus affinis		U						
Axonopus furcatus								T
Baccharis angustifolia					U			
Baccharis glomeruliflora					T			
Baccharis halimifolia			U	T,U		W		W,T
Bacopa caroliniana							W	W,T
Berchemia scandens					T,U			
Bidens pilosa			U	U				
Blechnum serrulatum						W		
Boehmeria cylindrica						W		
Borrichia frutescens				T				
Bumelia celastrina				U				
Callicarpa americana					U	U	U	U
Carex glaucescens						W		
Carphephorus corymbosus		U						
Carpinus caroliniana	W							
Cassytha filiformis				T,U				
Cenchrus longispinus				U				
Centella asiatica	W					T	T	
Cephalanthus occidentalis	W		T			W	W,T	W
Chamaesyce maculata				U				
Chiococca alba				U				
Chionanthus virginiana						U	U	U
Cicuta mexicana			T			W		
Cinnamomum camphora			U					

(Continued)

* Code to communities:
MBR Morris Bridge riverine cypress swamp
MBM Morris Bridge freshwater marsh
BS Bayhead swamp
MS Mangrove swamp
SM Saltwater marsh
HC Hillsborough cypress swamp
HM Hillsborough marsh
HSS Hillsborough shrub swamp

** Code to Zones:
W--Wetland
T--Transition
U--Upland

(Sheet 1 of 5)

Table A3 (Continued)

Species	Community and Zone							
	MBR	MBM	BS	MS	SM	HC	HM	HSS
Cirsium horridulum			U					
Cladium jamaicense					T,U			
Coccoloba uvifera				U				
Conocarpus erecta				T				
Conyza canadensis				U				
Coreopsis leavenworthii				U				T
Croton glandulosus				U				
Cynanchum scoparium					T,U			
Cyperus brevifolius			U					
Cyperus haspan								W,T
Cyperus tetragonus				U				
Desmodium paniculatum				U				
Dichanthelium angustifolium	W,U				U	T,U	T,U	U
Dichromena colorata					U			
Diodia virginiana				U		T		T
Diospyros virginiana		U	U		U	U	U	T,U
Distichlis spicata				T	W			
Drosera capillaris		U					T	
Eleocharis baldwinii		W,U				W,T	T	
Eleocharis cellulosa							W	
Elephantopus elatus			U		U			
Erechtites hieracifolia						W		
Erigeron vernus		U						
Eriocaulon compressum							T	
Eriocaulon decangulare						T	T	
Eupatorium aromaticum			U		U			
Eupatorium capillifolium			U			W,T	T	
Eupatorium mikanioides					T,U			
Eustachys glauca				U				
Fimbristylis caroliniana					U			
Fimbristylis castanea				T	W,U			
Flaveria linearis				U				
Forestiera segregata				U	U			
Fraxinus caroliniana	W,T							
Fuirena breviseta								T
Galactia elliottii	U							
Galactia volubilis				U				
Gaylussacia dumosa						U	U	U
Gaylussacia frondosa			T,U			U	U	U
Gelsemium sempervirens						U	U	U
Gleditsia aquatica	W							
Gordonia lasianthus			W,U					
Hedyotis procumbens		U	U					
Helianthus radula					U			
Helianthus similans			U					
Heterotheca sp.		U						
Hydrocotyle umbellata	W	W	U					W
Hydrolea corymbosum								W,T
Hypericum cistifolium		U				T	T	
Hypericum fasciculatum		W,T				T	W,T	
Hypericum hypericoides	T		T			T		
Hypericum multilum								T
Hypericum tetrapetalum		U	T					
Hyptis alata					U	T		W,T
Ilex cassine			W		U	U	T,U	U

(Continued)

(Sheet 2 of 5)

Table A3 (Continued)

Species	Community and Zone							
	MBR	MBM	BS	MS	SM	HC	HM	HSS
Ilex glabra	U	T,U	T,U		U	U	U	U
Ilex vomitoria					U			
Iris hexagona						W		
Iva frutescens				T	T			
Iva microcephala					U			
Juncus biflorus								T
Juncus effusus								W,T
Juncus repens			W					
Juncus roemerianus					W,T			
Juncus scirpoides								T
Juniperus silicicola				U	U			
Justicia ovata	W							
Kosteletzkya virginica					T			
Lachnanthes caroliniana			W,T,U			W,T	T	
Laguncularia racemosa				W,T				
Leucothoe populifolia			W					
Limonium carolinianum					W			
Lindernia grandiflora						W		
Linum medium var. *texanum*					T			
Liquidambar styraciflua					U	T,U	U	U
Ludwigia linearis						T	T	
Ludwigia maritima						U	U	U
Ludwigia peruviana							W	W,T
Ludwigia repens		W	T					T
Lycium carolinianum				T				
Lycopus rubellus						W		
Lyonia fruticosa	U	U	U		U	U	U	U
Lyonia ligustrina			T					
Lyonia lucida	U	T,U	W			U	U	U
Lynthrum alatum								W,T
Lythrum lineare					W			
Magnolia grandiflora		U						
Magnolia virginiana			W		U			
Melanthera nivea					U			
Micranthemum glomeratum								W
Mikania scandens					T,U			W,T
Monarda punctata				U				
Myrica cerifera	W,T,U	T,U	W,T,U	U	U	W,U	T,U	U
Nymphaea odorata		W						
Nymphoides aquatica		W					W	
Nyssa sylvatica var. *biflora*	W		W			W		
Opuntia stricta				U				
Osmunda cinnamomea			T,U					
Panicum anceps	W,T							
Panicum breve			U				T	
Panicum gymnocarpon						T		
Panicum hemitomon		W					W,T	T
Panicum hians							W,T	
Panicum verrucosum			W,T					
Panicum virgatum				U	W,T,U			
Panicum xalapense			U					
Parthenocissus quinquefolia					U	U	U	U
Passiflora incarnata			U					
Persea palustris	W	T	W,T,U			U	U	U
Petalostemum carneum					U			

(Continued)

(Sheet 3 of 5)

Table A3 (Continued)

Species	Community and Zone							
	MBR	MBM	BS	MS	SM	HC	HM	HSS
Philoblephis rigida	U					U	U	U
Phyla nodiflora					T,U			
Phyllanthus abnormis				U				
Physalis angulata					U			
Pinus elliottii	T,U	T		U	U			
Pinus palustris		U	U			U	U	U
Pluchea rosea			W,T		U	W,T	W,T	T
Poinsettia heterophylla				U				
Polygala cymosa							T	
Polygonum hydropiperoides		W	W,T					W,T
Polypremum procumbens						T		
Pontederia cordata		W					W	
Proserpinaca pectinata		W	W,T			T	T	
Pteridium aquilinum	U		U		U	U	U	U
Pterocaulon virgatum		U			U	U	U	U
Pyrus arbutifolia		T						
Quercus geminata			U					
Quercus incana			U					
Quercus laevis			U					
Quercus laurifolia	W,T,U	T,U	W,U			W,T,U	U	W,T,U
Quercus nigra		U	U			T,U	U	T,U
Quercus pumila					U	U	U	U
Quercus virginiana	U	U	U		U	U	T,U	U
Rhizophora mangle				W,T				
Rhus copallina	U	U			U	U	U	U
Rhynchelytrum repens				U				
Rhynchosia reinformis				U				
Rhynchospora inundata		W					W	
Rhynchospora miliacea						W		
Rhynchospora tracyi							W,T	
Rotala ramosior								W,T
Rubus betulifolius			U					
Rubus cuneifolius	U		U					
Sabal palmetto	W,T,U		U	U	U	W,U	U	U
Sabatia difformis		U						
Sagittaria graminea		W					W	
Salix caroliniana						W		W
Sambucus canadensis						W		
Samolus ebracteatus				T	U			
Saururus cernuus	W							
Schinus terebinthifolius				U				
Scleria ciliata						T		
Scleria triglomerata		U	T,U					
Serenoa repens	T,U	U	T,U	U	U	U	U	U
Sesuvium portulacastrum				T				
Setaria geniculata					T,U			
Smilax auriculata	T,U		U	U		U	U	U
Smilax bona-nox	W,T				U			
Smilax laurifolia			W			U	U	U
Smilax walteri			T			W		
Solidago fistulosa		U	U		U	T		
Solidago microcephala		U	U		U			
Solidago sempervirens				T,U	W,T,U			
Solidago tortifolia					T,U			
Sophora tomentosa				T,U				

(Continued)

(Sheet 4 of 5)

Table A3 (Concluded)

Species	Community and Zone							
	MBR	MBM	BS	MS	SM	HC	HM	HSS
Sorghastrum secundum			U					
Spartina patens					W,T			
Spirodela polyrrhiza								W
Stenotaphrum secundatum				T,U				
Stillingi sylvatica					U	U	U	U
Taxodium ascendens						W		
Taxodium distichum	W							
Thelypteris interrupta						W		
Thelypteris normalis						W		
Toxicodendron radicans	U			U	T,U			
Triadenum virginicum		W,U				W		
Trichostema suffrutescens			U					
Typha domingensis								W
Ulmus americana var. *floridana*	W					U	U	U
Utricularia purpurea							W	
Utricularia subulata		U						
Vaccinium corymbosum			W,T,U					
Vaccinium darrowii			U			U	U	U
Vaccinium myrsinites		U				U	U	U
Viburnum obovatum	W							
Vigna luteola				U				
Viola affinis			U					
Vitis rotundifolia	U		T,U			T,U	U	U
Woodwardia areolata						W		
Woodwardia virginica	U		W,T,U			W		
Xyris ambigua							T	
Xyris brevifolia						T		
Xyris caroliniana							T	
Xyris jupicai		W						
Yucca aloifolia				U				
Zanthoxylum clava-herculis			U					

(Sheet 5 of 5)

APPENDIX B: IMPORTANCE VALUES FOR PHASE I COMMUNITIES

Table B1

Importance Values of Species in Wetland, Transition, and Upland Zones in Aripeka Saltwater Marsh Site*

Stratum and Species	Wetland	Transition	Upland
Tree			
Pinus elliotti	--	--	100.2
Sabal palmetto	--	--	80.7
Ilex cassine	--	--	50.4
Juniperus silicicola	--	--	36.3
Shrub			
Serenoa repens	--	--	130.5
Sabal palmetto	--	--	15.6
Myrica cerifera	--	--	41.7
Ilex cassine	--	--	25.8
Quercus virginiana	--	--	18.9
Iva frutescens	--	300.0	--
Ilex glabra	--	--	21.3
Herb			
Juncus roemerianus	148.8	47.8	--
Cladium jamaicense	--	91.6	--
Solidago tortifolius	--	14.6	--
Phyla nodiflora	--	9.0	--
Distichlis spicata	8.4	--	--
Solidago sempervirens	20.6	9.2	8.4
Panicum virgatum	4.0	5.4	26.6
Toxicodendron radicans	--	5.4	7.2
Ilex glabra	--	9.4	21.6
Samolus ebracteatus		2.0	--
Smilax bona-nox	--	--	60.4
Rhus copallina	--	--	7.2
Quercus pumila	--	--	13.4

* Species which occurred with frequency less than 20 percent were not included. Zones were chosen subjectively.

Table B2

Importance Values of Species in Wetland, Transition, and Upland Zones in Hillsborough River Freshwater Marsh*

Stratum and Species	Wetland	Transition	Upland
Trees			
Quercus nigra	--	--	117.0
Pinus palustris	--	--	83.1
Quercus laurifolia	--	--	33.0
Sabal palmetto	--	--	18.0
Diospyros virginiana	--	--	24.9
Shrub			
Cephalanthus occidentalis	290.4	8.1	--
Hypericum fasciculatum	9.9	274.8	--
Serenoa repens	--	--	190.5
Quercus nigra	--	--	38.4
Ilex glabra	--	--	21.0
Lyonia lucida	--	--	28.8
Herb			
Panicum hemitomon	38.4	3.4	--
Rhynchospora inundata	60.4	--	--
Pontederia cordata	24.4	--	--
Nymphoides aquatica	11.8	--	--
Rhynchospora tracyi	19.6	--	--
Eleocharis cellulosa	12.6	--	--
Bacopa caroliniana	6.2	--	--
Cephalanthus occidentalis	7.8	2.0	--
Panicum hians	--	5.0	--
Amphicarpum muhlenbergianum	--	61.6	--
Lachnanthes caroliniana	--	28.4	--
Eriocaulon decangulare	--	14.0	--
Centella asiatica	--	9.0	--
Eleocharis baldwinii	--	14.1	--
Proserpinaca pectinata	--	14.8	--
Hypericum fasciculatum	--	9.4	--
Vitis rotundifolia	--	--	28.2
Quercus nigra	--	--	57.0
Smilax auriculata	--	--	15.4

* Species which occurred with frequency less than 20 percent were not included. Zones were chosen subjectively.

Table B3

Importance Values of Species in Wetland, Transition, and Upland Zones in Hillsborough River State Park Shrub Swamp*

Stratum and Species	Wetland	Transition	Upland
Tree			
Pinus palustris	--	--	83.1
Quercus laurifolia	--	--	80.7
Quercus nigra	--	--	48.9
Shrub			
Ludwigia peruviana	198.6	169.8	--
Cephalanthus occidentalis	72.3	--	--
Acer rubrum	12.3	60.3	--
Diospyros virginiana	--	34.8	--
Serenoa repens	--	--	190.5
Quercus nigra	--	9.0	38.4
Ilex glabra	--	--	21.0
Herb			
Spirodela polyrhiza	28.6	--	--
Typha domingensis	66.2	--	--
Polygonum hydropiperoides	26.8	4.4	--
Bacopa caroliniana	4.0	45.6	--
Lythrum alatum	4.4	22.6	--
Hyptis alata	2.4	13.0	--
Mikania scandens	2.8	11.6	--
Hydrolea corymbosum	4.0	11.6	--
Juncus effusus	4.0	7.4	--
Rotala ramosior	3.8	5.8	--
Panicum hemitomon	--	43.0	--
Diodia virginiana	--	7.4	--
Coreopsis leavenworthii	--	6.0	--
Juncus biflorus	--	4.4	--
Vitis rotundifolia	--	--	28.2
Quercus nigra	--	--	57.0
Serenoa repens	--	--	172.0
Ilex glabra	--	--	12.2
Smilax auriculata	--	--	15.4

* Species which occurred with frequency less than 20 percent were not included. Zones were chosen subjectively.

Table B4

Importance Values of Species in Wetland, Transition, and Upland Zones in Hillsborough River Cypress Swamp*

Stratum and Species	Wetland	Transition	Upland
Tree			
Taxodium ascendens	158.1	--	--
Nyssa sylvatica var. *biflora*	98.7	--	--
Myrica cerifera	23.4	--	--
Acer rubrum	15.0	--	--
Quercus nigra	--	--	80.7
Quercus laurifolia	--	--	48.9
Pinus palustris	--	--	126.9
Shrub			
Cephalanthus occidentalis	231.9	--	--
Myrica cerifera	24.6	--	--
Acer rubrum	15.6	--	--
Quercus nigra	--	50.1	13.5
Quercus laurifolia	--	19.8	--
Liquidambar styraciflua	--	189.3	--
Serenoa repens	--	--	25.8
Ilex glabra	--	--	21.6
Herb			
Lycopus rebellus	107.6	--	--
Blechnum serrulatum	45.2	--	--
Amphicarpum muhlenbergianum	--	97.0	--
Eriocaulon decangulare	--	19.0	--
Eleocharis baldwinii	--	8.8	--
Eupatorium capillifolium	--	6.6	--
Smilax auriculata	--	--	13.8
Quercus laurifolia	--	--	8.6
Vitis rotundifolia	--	5.4	85.2
Quercus nigra	--	--	80.6

* Species which occurred with frequency less than 20 percent were not included. Zones were chosen subjectively.

APPENDIX C: IMPORTANCE VALUES FOR PHASE II COMMUNITIES

Table C1

Importance Values of Species in Wetland, Transition, and Upland Zones in Morris Bridge Freshwater Marsh*

Stratum and Species	Wetland	Transition		Upland
Trees				
Pinus palustris	--	--		145.2
Quercus nigra	--	--		112.5
Quercus virginiana	--	--		25.8
Shrub				
Ilex glabra	--	76.8		102.0
Lyonia lucida	--	42.0		22.5
Serenoa repens	--	--		136.5
		Zone 1	Zone 2	
Herb				
Sagittaria graminea	50.8	17.8	44.4	--
Panicum hemitomon	31.8	--	47.2	--
Xyris jupicai	29.8	48.6	4.4	--
Pontederia cordata	25.0	0	39.4	--
Hydrocotyle umbellata	13.0	11.6	10.4	--
Triadenum virginicum	11.6	18.0	5.4	--
Nymphoides aquatica	11.4	0	19.6	--
Andropogon virginicus	--	5.2	--	--
Woodwardia virginica	--	8.4	--	--
Ludwigia repens	3.2	7.6	--	--
Centella asiatica	--	6.8	--	--
Eleocharis baldwinii	10.0	58.0	--	58.0
Rhynchospora inundata	3.2	4.0	--	--
Proserpinaca pectinata	3.2	5.0	--	--
Solidago fistulosa	--	--	--	45.0
Aristida stricta	--	--	--	30.6
Aristida spiciformis	--	--	--	17.4
Andropogon cabanisii	--	--	--	15.0
Lyonia lucida	--	--	--	11.2
Hypericum tetrapetalum	--	--	--	8.4
Dichanthelium sp.	--	--	--	8.0
Aster reticulatus	--	--	--	6.0
Solidago microcephala	--	--	--	5.6
Vaccinium myrsinites	--	--	--	4.8
Axonopus affinis	--	--	--	4.4

* Species which occurred with a frequency less than 20 percent were not included. Zones were chosen subjectively. Transition in the herbaceous layer is divided into one zone adjacent to wetland and a second zone adjacent to upland.

Table C2

Importance Values of Species in Wetland, Transition, and Upland Zones in Morris Bridge Riverine Cypress Swamp*

Stratum and Species	Wetland	Transition	Upland
Tree			
Taxodium distichum	112.8	--	--
Quercus laurifolia	46.8	229.2	57.6
Fraxinus caroliniana	38.1	--	--
Nyssa biflora	16.5	--	--
Persea palustris	14.1	--	--
Pinus elliottii	--	62.4	162.6
Sabal palmetto	6.3	8.4	43.8
Shrub			
Fraxinus caroliniana	130.5	11.7	--
Quercus laurifolia	78.3	111.9	15.0
Viburnum obovatum	52.8	--	--
Serenoa repens	--	130.5	201.6
Myrica cerifera	12.6	11.7	35.4
Herb			
Panicum anceps	103.2	50.8	--
Fraxinus caroliniana	23.4	--	--
Smilax bona-nox	22.8	115.2	--
Centella asiatica	19.8	--	--
Justicia ovata	15.0	--	--
Pteridium aquilinum	--	--	48.4
Woodwardia virginica	--	--	35.6
Galactia elliottii	--	--	24.4

* Species which occurred with frequency less than 20 percent were not included. Zones were chosen subjectively.

Table C3

Importance Values of Species in Wetland, Transition, and Upland Zones in Bayhead Freshwater Swamp*

Stratum and Species	Wetland	Transition Zone 1	Transition Zone 2	Upland
Tree				
Persea palustris	79.5	--	--	15.6
Nyssa sylvatica var. *biflora*	65.1	--	--	--
Myrica cerifera	42.3	--	--	30.6
Pinus palustris	--	--	--	174.0
Shrub				
Vaccinium corymbosum	90.9	49.8	--	8.4
Persea palustris	80.1	168.3	--	--
Myrica cerifera	9.9	24.9	21.0	--
Lyonia ligustrina	--	--	75.3	--
Serenoa repens	--	--	152.4	152.7
Ilex glabra	--	--	43.2	18.9
Herb				
Juncus repens	44.2	--	--	--
Lachnanthes caroliniana	8.4	109.6	--	--
Polygonum hydropiperoides	5.2	3.6	--	--
Proserpinaca pectinata	3.8	9.0	--	--
Hypericum cistifolium	--	13.6	--	--
Woodwardia virginica	83.2	19.4	--	11.2
Smilax laurifolia	16.8	--	--	--
Ilex glabra	--	--	8.6	20.6
Aster reticulatus	--	--	38.2	--
Osmunda cinnamomea	--	--	132.6	--
Solidago microcephala	--	--	--	16.2
Myrica cerifera	--	--	11.0	--
Aristida stricta	--	--	--	17.2
Solidago fistulosa	--	--	--	13.4
Vaccinium darrowii	--	--	--	6.4
Panicum breve	--	--	--	6.4

* Species which occurred with a frequency less than 20 percent were not included. Zones were chosen subjectively. Transition zone is divided into one zone adjacent to wetland and a second zone adjacent to upland.

Table C4

Importance Values of Species in Wetland, Transition, and Upland Zones in Honeymoon Island Mangrove Swamp*

Stratum and Species	Wetland	Transition	Upland
Tree			
Rhizophora mangle	144.6	--	--
Avicennia germinans	93.3	--	--
Laguncularia racemosa	62.1	--	--
Pinus elliotti var. *densa*	--	--	144.6
Myrica cerifera	--	--	45.9
Shrub			
Rhizophora mangle	177.9	11.1	--
Avicennia germinans	78.6	54.3	--
Laguncularia racemosa	43.5	91.8	--
Conocarpus erecta	--	84.0	--
Yucca aloifolia	--	--	48.0
Herb			
Rhizophora mangle	20.0	--	--
Avicennia germinans	144.0	--	--
Laguncularia racemosa	36.2	2.0	--
Distichlis spicata	--	85.6	--
Aster subulata	--	11.6	--
Sesuvium portulacastrum	--	8.6	--
Fimbristylis castanea	--	10.0	--
Cassytha filiformis	--	5.8	--
Stenotaphrum secundatum	--	2.0	23.2
Bidens pilosa	--	--	17.0
Rhynchelytrum repens	--	--	12.4
Toxicodendron radicans	--	--	17.2
Diodia teres	--	--	7.8
Eustachys glauca	--	--	8.8
Rhynchosia reniformis	--	--	6.6

* Species which occurred with a frequency less than 20 percent were not included. Zones were chosen subjectively.

APPENDIX D: GLOSSARY

(Definitions used in this Glossary refer to the context in which the words are used in this report and are not intended to be general definitions.)

Definition of Terms

abundance--Species quantity or magnitude. Can be measured by a variety of parameters, e.g., biomass, percent cover of ground area, basal area.

belt transect--A strip of sampling area of specified width that permits continuous sampling over the area traversed.

density--The number of individuals per unit area.

dominance--Total basal area or percent cover of a tree or clumped herbaceous species in a stand.

frequency--The number of sample points in which a species occurs divided by the total number of sampling points.

gradient--A monotonic change in value with change in a given variable; e.g., change of moisture availability with change in distance.

hydroperiod--The length of time an area is flooded or saturated with water.

hydrophyte--A plant species that requires frequent inundation or saturated soil conditions to persist under natural conditions.

importance value (IV)--A synthetic index combining two or more vegetational parameters (i.e., frequency, density, dominance).

ordinate--To arrange species or sample stands along one or more environmental gradients so that the ecological differences between the units are represented by distance.

ordination--A ranking of species along one or more environmental gradients. In direct ordination, the gradient is known. In indirect ordination, the comparison between species relationships and environmental values reveals gradients that are most significant in determining species distribution.

parameter--A property that can be measured to determine the characteristics or behavior of something.

percent cover (PC)--The percent of a plot occupied by a projection of the canopy on the ground or, for trees, a projection of the basal area.

percent similarity (PS)--A measure of the similarity of species composition between two samples.

physiognomy--A description of the gross morphology of the vegetation of an area (forests, shrublands, grasslands, etc.).

relative abundance--A measure of abundance for one species divided by the combined values of that measure for all species present.

replicate--One of several identical experiments, procedures, or samples.

seral stage--A stage in the succession of a plant community to a stable species composition, or the species composition that would eventually occur in the absence of disturbance.

species-area curves--A graph of the cumulative number of species encountered in a community with each additional sample.

transform--To change the scale and relationships of a series of values by applying a constant mathematical treatment; e.g., log of the value or square root of the value.

transition zone--Zone between wetland and upland community where vegetation changes from predominantly hydrophytic species to species intolerant of flooding.

upland--An area where all vegetation is intolerant of flooding.

weighted average (WA)--An average obtained by multiplying each value by its position on a gradient and dividing the sum of these by the sum of the unweighted values.

wetland--Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

APPENDIX E

Table E1

National Wetlands Inventory (NWI) Equivalents of Wetland Types Used in This Report

Wetland Type	NWI Equivalent
Saltwater aquatic	Marine, aquatic bed, rooted vascular
Saltwater coastal flat	Marine, unconsolidated bottom, mud
Saltwater swamp	Estuarine, forested, broad-leaved evergreen
Mangrove swamp	Estuarine, forested, broad-leaved evergreen
Saltwater marsh	Estuarine, emergent, persistent
High marsh	Estuarine, emergent, persistent
Low marsh	Estuarine, emergent, persistent
High saltmarsh	Estuarine, emergent, persistent
Shallow water marsh	Estuarine, emergent, persistent
Freshwater aquatic	Palustrine, aquatic bed, rooted vascular
Freshwater flat	Palustrine, emergent, persistent
Freshwater marsh	Palustrine, emergent, persistent
Shrub swamp	Palustrine, scrub-shrub, broad-leaved deciduous
Hardwood hammock	Palustrine, forested, broad-leaved deciduous
Mixed hardwood swamp	Palustrine, forested, broad-leaved deciduous
Bayhead swamp	Palustrine, forested, broad-leaved evergreen
Cypress swamp	Palustrine, forested, needle-leaved evergreen
Riverine cypress swamp	Palustrine, forested, needle-leaved evergreen
Cypress domes	Palustrine, forested, needle-leaved evergreen
Alluvial cypress swamp	Palustrine, forested, needle-leaved evergreen

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